a la Precis 2.

The Control and Reporting System.

The activities of the tactical control, fighter control and reporting are dependent on each other, and are therefore best carried out by a single organisation. This organisation is known as a Control and reporting (C. & R.) system.

Reporting Organisation.

(1) Provides a continuous and current air-picture by means of a chain of radar stations and ground observer teams.
(2) Gives early warning of the approach of enemy aircraft and long range missiles.

The air picture is displayed to its many users by means of general situations maps (G.S.M.'s). A G.S.M. is a map of a defended area (or part of it) and its approaches upon which annotated symbols are moved to indicate air activity.

These symbols show the position, direction of flight, strength and height of each unit of air activity. This process is known as track production. They must also show the identification of the track, this is known as raid recognition.

Fighter Control

The fighter control system must:-
(a) Possess complete radar cover over the defended area and its approaches;
(b) Have an efficient method of communication with airborne fighter aircraft;
(c) Continue to operate through radar and radio interference;
(d) Not breakdown when the enemy employs "Saturation" tactics, i.e. Mass raids designed to cause confusion by numbers.

Tactical Control

The tactical control organisation must :-
(a) Ensure that weapons are held at suitable states of preparedness;
(b) Meet every attack with the best use of weapons available;
(c) Ensure the most economical use of weapons when attacked by superior enemy forces.
(d) Co-ordinating the effort of the air defences of the whole area.

STATIC AND MOBILE AIR DEFENCE SYSTEMS

(1) Static Air Defence System
This type of system (e.g. that of the United Kingdom) is suited to the defence of a large area containing the resources on which a nation depends for the prosecution of a major war.

(2) Mobile Defence Systems
This type (e.g. that of the 2nd T.A.F.) is best suited for areas where the land battles are expected to be fluid and may be more economical for those areas which are large compared with the forces available for their air defence.

In the lectures which will follow this we will concentrate on the static system, in particular the C & R activities of the Air Defence System of Great Britain.

AIR DEFENCE SYSTEM

1. Function - to protect the defended area from Air attack (including the landing of airborne troops) by:-

   (a) Destroying enemy aircraft

   (b) Harassing enemy aircraft, thereby reducing the accuracy of their attack.

   (c) Minimising the effects of successful attacks

2. The system must possess:-

   (a) Suitable weapons

   (b) Means of using these weapons

   (c) An organisation by which the system can be alerted.

3. The weapons of air defence in present use are :-

   (a) Fighter aircraft
      (i) Day Fighters
      (ii) All-weather fighters.

   (b) Anti-aircraft artillery (A.A.)
      (i) Heavy A.A.
      (ii) Light A.A.

   (c) Guided Missiles.

   (d) Defensive radio-countermeasures.

   (e) Decoy targets.

   (f) Smoke screens.

   (g) Searchlights.

   (h) Balloons.

   (i) Means of target effacement (camouflage, blackout, subterranean siting, etc.)

   (j) Fortifications.

   (k) Civil Defence Services.

4. Means required for using these weapons :-

   (a) Airfield and launching sites.

   (b) Air navigation and landing aids.

   (c) Communications.

   (d) Supply services.

   (e) Skilled personnel.

   (f) A tactical control organisation to ensure that the weapons are put to the best use,

   (g) A fighter control system for guiding fighters towards attacking enemy aircraft.

   (h) A reporting system to assist the control system and to alert the air defences.

   (i) An intelligence system to provide information on the movement of enemy formations outside the range of the reporting system and any relevant advance information available.

RESPONSIBILITIES FOR CONTROL IN THE C. & R. SYSTEM

Air Defence Operations Centre

The responsibilities of the Controller at the A.D.O.C. and details of his staff are being worked out at present.

Sector Controller

The Sector Controller is responsible to the Sector Commander for the efficient employment of the active and passive air defence in the Sector and subject to orders which may be issued by the Sector Commander, is responsible for:-

(a) Assessing the enemy threat to his own Sector
(b) Ordering the States of Readiness that are to be maintained
(c) Issuing orders regarding the actions to be taken to meet the enemy threat against his own Sector including:-

(i) Ordering off fighters
(ii) Orders for Control of A.A. Defences
(iii) D.R.W. (Defensive Radio Warfare)

(d) Control of smoke screens in agreement when necessary with the adjacent Sector Controllers.

(e) Issuing executive orders to implement the instructions of the Air Defence Controller and supplying the Air Defence Controller with all information that he needs for the efficient conduct of current operations

(f) Liaison with other Sector Controllers

(g) Control of aircraft movements within his Sector as required in the current instructions for routeing and recognition of aircraft

(h) The safety of aircraft under control, under all weather conditions

(j) The reinforcement of other Sectors as ordered by the Air Defence Controller

Air Executive

The Air Executive is responsible to the Sector Controller for:-

(a) The execution of his orders on States of Readiness

(b) Diversion to and from the Sector's airfields

(c) Providing to the Sector Controller and having displayed on the Tote all relevant and up to date information concerning:-

(i) The availability of the Sector's Fighter force
(ii) The weather state
(iii) The state of the airfields in the Sector

(d) Briefing Wing Operations Rooms on the current air situation

(e) When so ordered, passing to airfields, scramble orders including the initial vector.

(f) Air/sea rescue.

(g) Liaison with Air Executive of adjacent Sectors.

Air Executive Assistant

In general his duties are to assist the Air Executive to fulfil his responsibilities. He is directly responsible to the Air Executive for:-

(a) The accuracy of the information displayed on the Squadron States and Airfield States Totes.

(b) Maintenance of Air Executive log.

(c) Forms "B"

(d) Forms "C"

Control Executive

The Control Executive is responsible to the Sector Controller for the tactical control of fighters and specifically for:-

(a) Allocating fighters to G.C.I. stations, and ordering the handover of fighters from one G.C.I. to another if required.

(b) Allocating V.H.F. R/T control channels to G.C.I. stations.

(c) Informing G.C.I. stations and Sector Fighter Marshals of the orders for the control of A.A. guns.

(d) Liaison with Chief G.C.I. Controllers in his Sector and the Control Executive of other Sectors.

(e) The safety of aircraft under control.

(f) Informing the Sector Controller of the progress of operations and advising him on the most effective forms of control.

Control Executive Assistant

Generally assists the Control Executive in all the above duties. He is directly responsible to the Control Executive for:-

(a) The accuracy of the information displayed on the Mission Tote and Fighter Table.

(b) Maintenance of the Control Executives Log.

Sector Fighter Marshal Organisation

Control of the Sector Fighter Marshal Organisation may be exercised either from the S.O.C. or from the selected G.C.I. at which Sector Fighter Marshals are situated.

If it is desired to exercise control from the S.O.C., a chief Sector Fighter Marshal is established and is responsible to the Sector Controller for:-

(a) Overall control of the Sector fixer system and their employment in accordance with the prevailing circumstances.

(b) The handling of all fighters not under G.C.I. control.

(c) Co-ordination of the work of the Sector Fighter Marshals.

(d) The safety of aircraft under control of his organisation.

<u>The Sector Fighter Marshal</u>

The Sector Fighter Marshal situated at a suitable G.C.I. is responsible for the control of aircraft in accordance with the orders of the Chief Sector Fighter Marshal, or in with the orders of the Control Executive and especially for:-

(a) Rapid handover of fighters on becoming airborne to G.C.I. stations.

(b) Control of aircraft awaiting G.C.I. control or returning to base, or in transit to another G.C.I., by means of radar and/or V.H.F. D/F fixes.

(c) Control and operation of one of the Sector V.H.F. D/F fixer systems.

(d) Safety of aircraft under his control.

(e) Plotting of fighters under his control to the local fighter display.

<u>"Rats" Controller</u>

To be issued later.

<u>Sector D.R.W. Officer</u>

The Sector D.R.W. Officer is the Sector Commander's adviser on all D.R.W. matters except D.R.W. Reporting. D.R.W. reporting is the operation of all facilities which convert enemy transmissions, window indications etc., into plot or track form.

The Sector D.R.W. Officer is responsible to the Sector Commander for:-

(a) Augmenting from monitoring or other sources of intelligence the D.R.W. information displayed on the G.S.M. so as to assist him in assessing:-

   (i) The enemy threat and intentions within the Sector
   (ii) The effect of enemy R.C.M. (Radio Counter Measures) on the operation of the C. & R. system
   (iii) The best operational tactics to be employed against R.C.M. aircraft

(b) Advising on various D.R.W. measures available to:-

   (i) Counter enemy R.C.M.
   (ii) Interfere with enemy radio system so as to make it difficult for him to carry out his intentions

(c) Initiating action on those measures which are under his control either directly or through the medium of the A.D.O.C.

(d) Liaison with A.D.O.C. and other Sectors on D.R.W. matters.

(e) Liaison with the Control Executive on the use of Sector D/F fixer networks for fixing enemy transmissions.

The Sector D.R.W. Officer is responsible to the Sector Signals Officer for:-

(a) Implementation of D.R.W. policy and instructions received from the Group and Command Staffs.

(b) D.R.W. facilities allotted to the Sector being used to the best advantage.

Chief G.C.I. Controller

The Chief G.C.I. Controller is responsible to the Control Executive for:-

(a) Tactical control of aircraft allotted to his G.C.I.

(b) The delegation of interceptions to Interception Controllers.

(c) Passing information regarding orders for control to Interception Controllers.

(d) Liaison with the adjacent Chief G.C.I. Controllers particularly in connection with the handover of fighters.

(e) The safety of aircraft under the control of his station.

Interception Controller

The Interception Controller is responsible to the Chief G.C.I. Controller for:-

(a) Carrying out the interception delegated to him.

(b) Safety of aircraft under his control.

(c) Ensuring the plotting of fighters under his control to the local Fighter display.

(d) Handing over fighters to adjacent G.C.I.'s as ordered by the Chief Controller.

G.C.I. Fighter Marshal

The G.C.I. Fighter Marshal is responsible to the Chief G.C.I. Controller for:-

(a) Control of fighters awaiting allocation to Interception Controllers or awaiting return to base under the Sector Fighter Marshals control.

(b) The safety of aircraft under his control.

(c) Ensuring the plotting of fighters under his control to the local Fighter Display.

(d) Handing over fighters to other channels as ordered by the Chief Controller.

RESPONSIBILITIES FOR CONTROL OF ANTI-AIRCRAFT GUNS IN THE C. & R. SYSTEM

American Liaison Officer at S.O.C.

The American Liaison Officer is responsible for:-

(a) Issuing in detail to the appropriate A.A.O.R.'s (A/A. ops Room) and A.A., State Board at the S.O.C., the fire control orders as directed by the Sector Controller.

(b) Imposing fire control orders after consultation with the Sector Controller to ensure the safety of friendly aircraft when they:-

- (i) Take off from the airfields
- (ii) Are returning to base
- (iii) Are crossing or about to cross the G.F.A.

(c) Relaxing gun restrictions in accordance with the Sector Controller's orders when the reason for gun restrictions has ended.

(d) Keeping A.A.O.R.'s informed of those major developments in the air battle, which are likely to affect them and maintaining close liaison with them so as to ensure smooth working between S.O.C. & A.A.O.R.

British L.A.A. Executive

The L.A.A. (Light A.A.) is responsible for:-

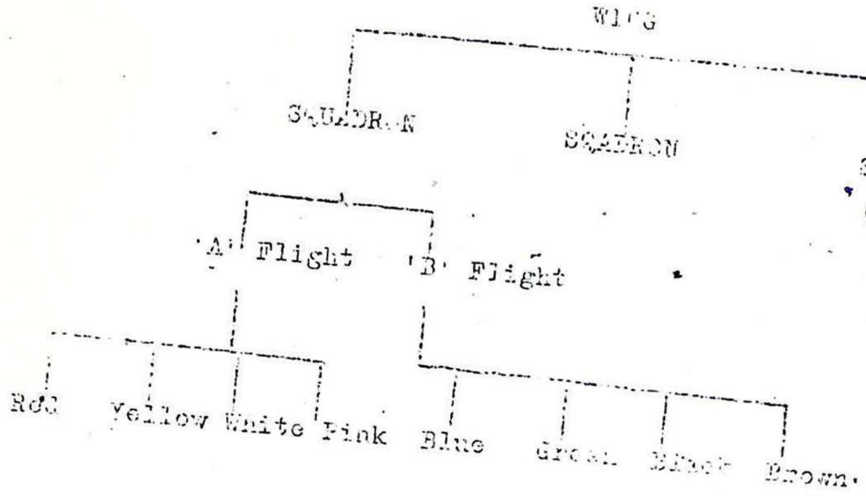
(a) Alerting L.A.A. Control Centres in his Sector.

(b) Implementing the Sector Controller's directions on the control of L.A.A. fire by giving the required control order.

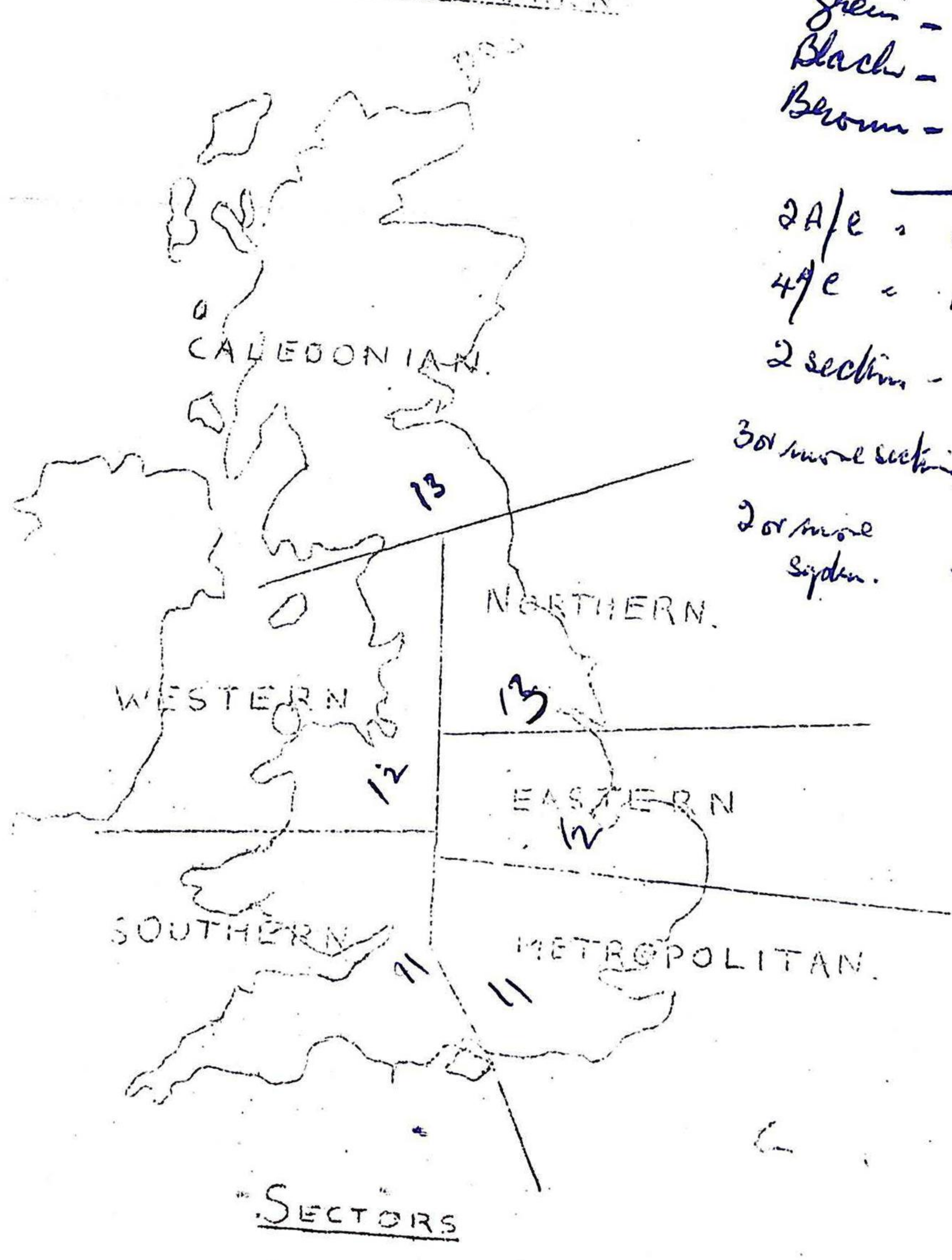
(c) Broadcasting plots if "Rats" from the Rat Table and all plots on the G.S.M. which are at 10,000 ft. and below and are within 100 miles radius over the sea of any L.A.A.C.C.

(d) To broadcast any other information which he considers of interest to the L.A.A. defences in the form of a sitrep.

2A.



WING ORGANISATION



SECTORS

Colours of Section

Wing - white on blac

Sqd - black on whi

FLTS. white on red o

Sections.

Red - white (word) sec on Red

Yellow - Black sec on yellow

White - Red sec on white B

Pink - Black sec on Pink B

Blue - white sec on Blue B

Green - White sec on Green B

Black - White sec on Black B

Brown - Black sec on Brown

2 A/c = 1 Pair.

4 A/c = 1 Section.

2 sections = 1 flt.

3 or more sections = 1 Sqdn.

2 or more Sqdn. = 1 Wing.

A.D.O.C.

General direction, co-ordination & re-inforcement of Sectors; D.R.W.

S.O.C.

Ordering states of preparedness, scrambling fighters; allocation of scrambled fighters to G.C.I.'s; integration of guns & fighters; D.R.W.

G.C.I.	Wg. Ops. Rm.	A.A.O.R.	L.A.A.C.C.
Fighter direction in the air.	Management of aircraft & aircrews on airfields	Management of H.A.A. guns in G.D.A.'s	Management of L.A.A. guns at vunerable points.

3/

C O N T R O L

1. Fighter Command is responsible for the air defence of the United Kingdom and the seas within 40 miles of the coast. The Air Officer Commanding in Chief, Fighter Command, is the Air Defence Commander Great Britain.

2. The command is divided into 2 groups, Nos. 11 & 12. These groups are again divided into sectors. Metropolitan and Southern Sectors are in 11 Group, Northern, Eastern, Western, and Caledonian sectors are in 12 Group.

3. Operational activities are centred in the Air Defence Operations Centre for each Sector.

4. The sectors are responsible for the minute-to-minute tactical control of operations. Command Headquarters is responsible for the broad control and co-ordination of the sectors.

5. While no tactical control is exercised from Group Headquarters, the group commander commands every unit in his group and is responsible for their operational, administrative and technical efficiency.

6. A.D.O.C.: The function of the A.D.O.C. is overall direction of the air battle, co-ordination of the efforts of the sectors reinforcement, and D.R..

7. GROUP WAR ROOM : The function of the group war room is to assist the group commander in effecting his duties. Information such as aircraft, and personnel strengths, airfield states etc., would be available. A G.S.M. may be provided.

8. S.O.C.: The principal duties of the S.O.C. are to:-

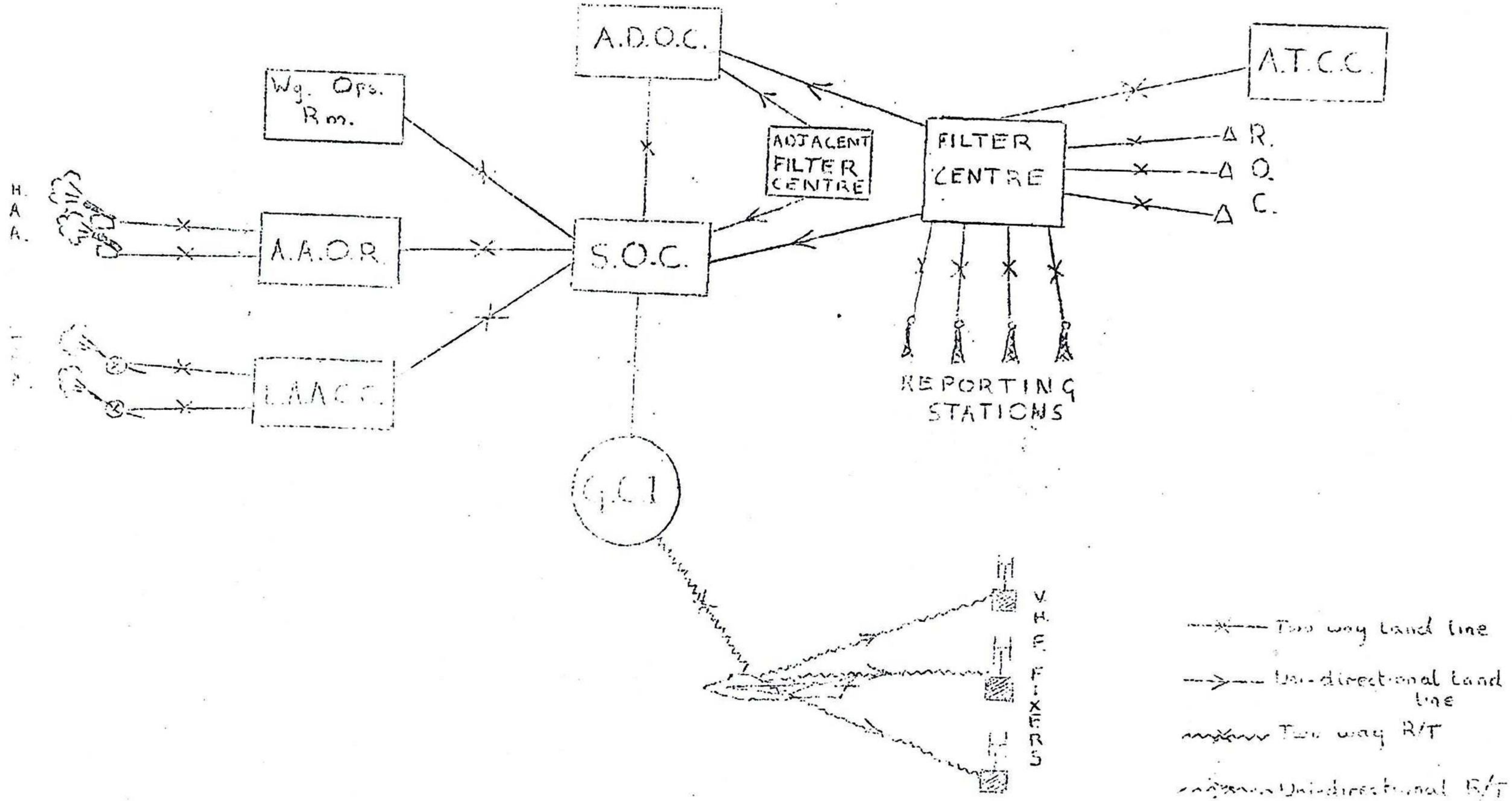
   (a) To scramble fighters against the enemy.
   (b) To allocate fighters to G.C.I's.
   (c) To maintain fighters at suitable states of preparedness.
   (d) To co-ordinate use of guns and fighters.
   (e) To direct local D.R.W.

9. G.C.I. STATIONS: G.C.I. stations guide scrambled fighters into contact with the enemy aircraft. Whenever possible in a way which will give the fighter the tactical advantage.

10. WING OPERATIONS ROOM: Situated on the fighter airfield it passes and implements the orders of the S.O.C. regarding states of preparedness and scramble orders for fighter aircraft.

11. A.A. OPERATIONS ROOM: An A.A.O.R. is situated in each G.D.A. It passes and implements the orders of the S.O.C. regarding the conditions under which the A.A.A. guns may fire at aircraft.

12. LIGHT A.A. CONTROL CENTRES (L.A.A.C.C.): Passes and implements the orders of the S.O.C. with regard to the light A.A. guns.



LINES OF COMMUNICATION

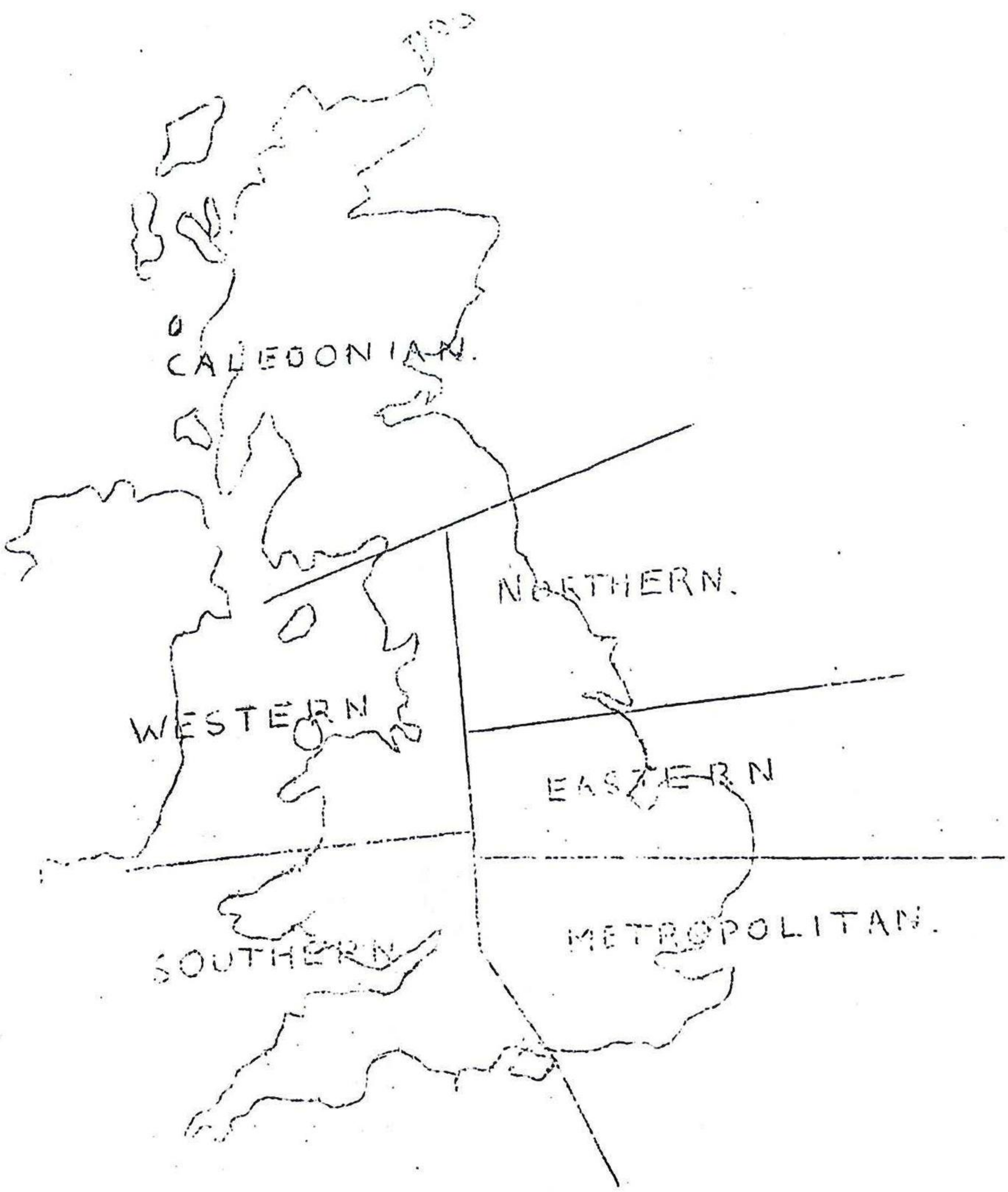
WING

SQUADRON SQADRON SQADRON

'A' Flight 'B' Flight

Red Yellow White Pink Blue Green Black Brown

WING ORGANISATION



SECTORS

FUNCTION OF THE S.O.C.

The responsibility for the defence of the Sector Area and the general co-ordination of fighter activity within that area under the direction of the Air Defence Commander is given to a centre known as the S.O.C.

The functions of the S.O.C. are as follows:-

a. To carry out all orders received from the Air Defence Commander about the ordering off of aircraft.

b. Ordering into the air (i.e. scrambling) fighters against the enemy.

c. Allocating the scrambled fighters to suitable ground control points (G.C.I. Stations).

d. To maintain a reserve of fighters at suitable states of preparedness to

   (i) To meet enemy attacks
   (ii) To provide protection while returned fighters are rearming and refueling

e. To bring fighter aircraft safely home again.

f. Co-ordinating guns and fighters to maximum advantage.

g. Directing the local D.R.W. effort.

h. To control air/sea rescue aircraft within the Sector Area.

Precis 6.

FUNCTION AND ORGANISATION OF SECTOR OPERATIONS CENTRE.

1. The United Kingdom and its seaward approaches are divided into several sectors. The Commander of each sector is responsible to the A.O.C in C Fighter Command for maintaining tactical control of the air defences - fighters and guns - deployed in his sector.

2. This task is undertaken at the Sector Operations Centre (SOC) and, because he cannot remain there continuously, he normally delegates these duties to senior officers who act as sector controllers on a watch basis.

3. A staff of 'executive officers' each with a particular operational function, implements the orders of the Sector Controller. (See precis "Executive Posts and Duties in the S.O.C.")

4. In order that the sector controller and key personnel may be kept fully informed of the progress of the air battle, various displays are maintained before them in the display hall.

Layout of Operations Room

The Sector Operations room consists essentially of:-
(a) A display hall in which are arranged:-
 (i) A.G.S.M.
 (ii) A Fighter Table.
 (iii) "Rat's" Table
 (iv) Continental Early Warning Screen.
 (v) A "Tote".

(b) A number of cabins from which the users observe these displays.

Displays

General Situation Map. The GSM is a display map in the form of a table on which the air picture produced by the Filter Centre and track plotted in adjacent sectors are displayed by means of symbols. The map shows:-
 (a) The sector area with boundaries clearly marked
 (b) Considerable areas of adjacent sectors.
 (c) Gun defended areas.
 (d) Other details considered of importance to the Controller (e.g. Sector airfields, GCI stations, large towns etc.)

Fighter Table. Tracks of airborne fighters under the sector's control together with tracks of targets (if an interception is being attempted) are displayed on this table by means of symbols. The map shows:-
 (a) The sector area in larger scale than the GSM but with only small areas of adjacent sectors.
 (b) Gun defended areas.
 (c) Sector airfields and GCI Stations.

"Rat's" Table "Rat" is the code word used to indicate low flying hostile or unidentified aircraft. Fighter aircraft employed solely for the task of intercepting such raids are known as 'terriers'. The "Rats" table is used to display "rat" and 'terrier' information upon a large scale map showing:-

(a) Coastal approaches to the sector area.
(b) Airfields from which 'Terrier Aircraft' operate
(c) Gun Defended. areas.

Coninental Early Warning Screen.

Tracks of enemy aircraft which may constitute a threat to the U.K. are passed direct from continental sources to vertical early warning screens at the S.O.C.

The screen consists of a vertical sheet of perspex on which is engraved a map of the continental approaches to the U.K., to a range of approximately 300 nautical miles. Plotters behind the screen display the air picture by means of wax pencils.

Tote Displays. To assist the sector controller and his executive staff, the entire wall opposite the control cabins is taken up by various tote displays comprising of:- (a) Squadron States Tote this shows the current states of readiness of the sector fighter squadrons as ordered by the sector controller.

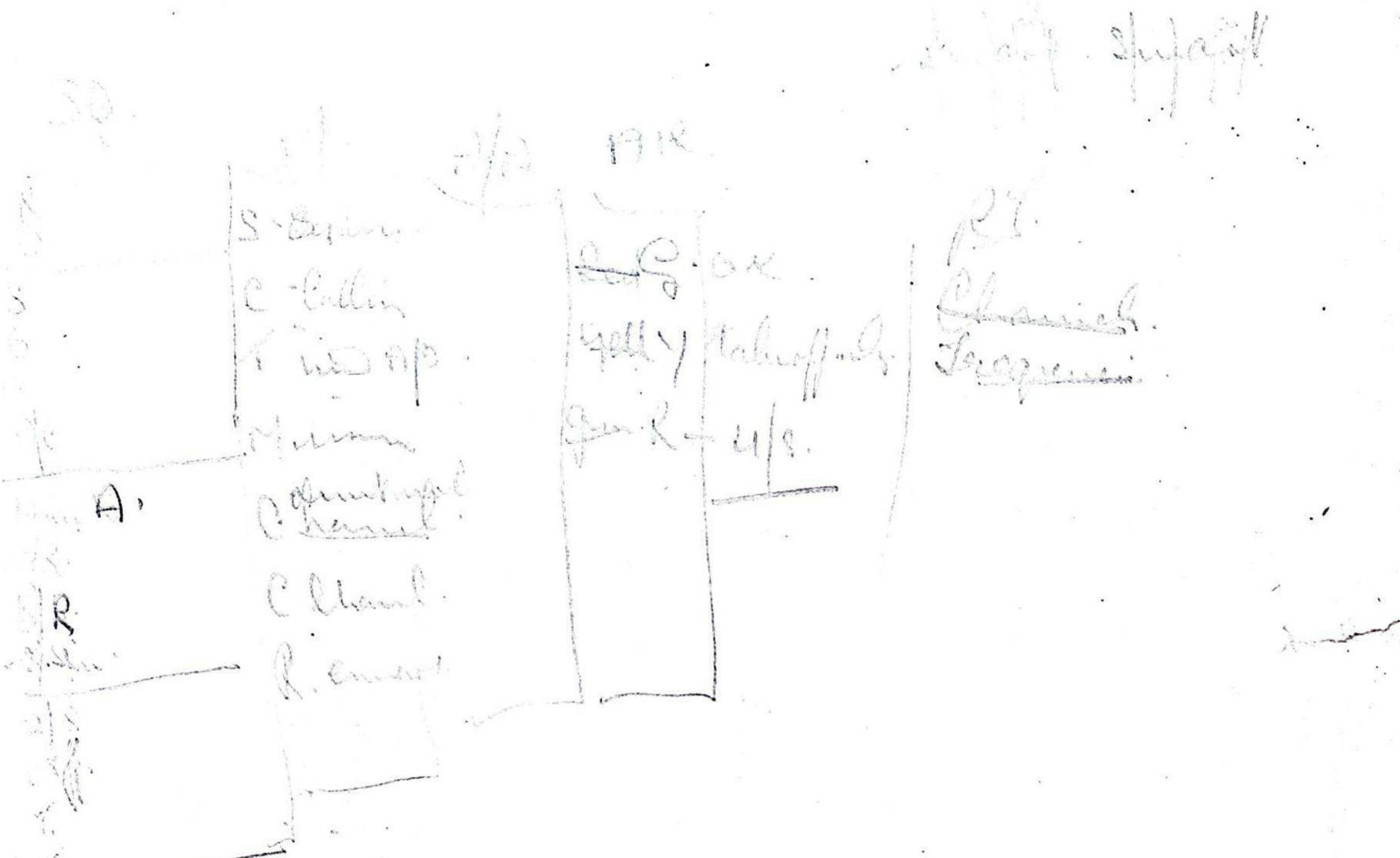
(b) Mission Tote This shows details of the mission on which fighter aircraft under the sectors control are engaged.

(c) A.A. States Board. This shows the various gun restrictions in force within the gun defended areas of the sector.

(d) Airfield States Board. This shows the current serviceability of sector airfields in terms of :-

1. Local weather conditions.
2. the aerodrome surface e.g. bomb damage.

(e) R/T Frequency Allocation Board. This display serves to remind the controllers of the availability of R/T frequencies both in the fighter aircraft and at G.C.I. Stations within the sector



Precis 6.

CREW DUTIES AT S.O.C.

G.S.M. PLOTTER

(a) Positions himself at the G.S.M. in such a manner that he has ready access to the area covered by his teller at the C.F.P.

(b) Plots and displays all information told to him as rapidly as possible (See precis"Method of displaying information")

(c) Ensures that all tracks told to him present an accurate and neat picture and that each track retains not more or less than three arrows after the first plots have been passed by the C.F.P.

(d) Removed tracks on which no further information is received during a complete colour change cycle and instructs the raid orderly to store the raid display stands of such tracks in the appropriate section of the Fade tray.

THE G.S.M. RAID ORDERLY

(a) Ensures that the plotters he serves are supplied immediately with all the display equipment as called for by them.

(b) Removes from the table all redundant equipment as instructed by the plotter and stores Raid Display Stands of faded tracks in the appropriate section of the Fade Tray for one complete colour change cycle, after which period the stands and ancillary equipment are stored in numerical and/or alphabetical order.

SECTOR FIGHTER IDENTIFICATION TELLER

Liason with the R.R.O. at the sector Filter Centre in the recognition of fighter tracks on Filter Centre tables. He is positioned overlooking the Sector Fighter Table and the Fighter Mission Tote, and his task is to link tracks of fighters with tracks on the G.S.M. He is provided with a two-way ringing circuit to the Raid Recognition Officer and as soon as fighter missions are placed on the Mission Tote he rings the R.R.O. and provides him with all the information displayed. When this information is modified or added to the R.R.O. is informed immediately. He should be ready to answer any queries from the R.R.O. on the whereabouts of any specific fighters as plotted on the Fighter Table. A log of events is kept.

TOTE OPERATORS

Work behind the totes, each of which comprises a large number of horizontal slots. Information is displayed by plaques which "hook on" to the slots.

The following are responsible for passing information to the tote operators:-

(a) Wing Operations Rooms at airfields pass changes in aircraft states as they are fulfilled. W

(b) Central Executive Assistant passes details Mission Tote and R/T Allocation Board. CEA C

(c) Air Executive Assistant who passes details affecting Squadron and Airfield States Totes. AEA AEA A

(d) H.A.A. Executive passes gun restriction orders to the A.A. States Board. H.

The passage of information to the tote is either:-

(a) Over landlines or (b) Over a loudspeaker system.

Sector Tote Teller and Recorder

Each Sector employs a tote teller and recorder who work as a team in the passing of details of the current display on each Sector's Squadron State and Mission Totes to the tote at the Air Defence Operations Centre. (For their duties see precis Tote Telling Procedures S.O.C. to A.D.O.C.)

Plotters and Raid Orderlies

In addition to the G.S.M. the air picture on the following tables and screens are displayed by symbols and require plotters and raid orderlies:-

(a) Fighter Table
(b) Rats Table
(c) Continental Early Warning Screen

Triangulation Room Crew

See precis (Triangulation Room Crew Personnel at S.O.C.)

The N.C.O. i/c Watch

He is responsible for the efficient working, training and regular changeover of all S.O.C. crew members. He monitors and checks plotting lines and maintains a watch log, detailing the duties of all personnel and noting any unusual occurrences. He reports all unserviceable equipment and obtains replacements from the Floor Supervisor.

The Floor Supervisor

He is responsible for the efficiency and discipline of all crew members. He ensures that all equipment is serviceable and obtains replacements. He is responsible for the control of the changeover panel and liaisons with the G.P.O. engineer. He checks all operational lines prior to commencement of watch, and maintains a log showing instructions issued by the controller and details of unserviceability etc.

PRECIS: F.P. No 7

EXECUTIVE POSTS AND DUTIES IN S.O.C.

The Sector Controller:

The Sector Controller is responsible to the Sector Commander for the efficient employment of the active and passive air defence in the Sector. He is responsible for:

(a). Assessing the enemy threat to his own Sector.
(b). Ordering the states of readiness that are to be maintained.
(c). Issuing orders regarding the action to be taken to meet the enemy threat against his own Sector including:-
  (i). Ordering off fighters.
  (ii). Orders for control of A.A. defences.
  (iii). D.R.W.
(d). Control of smoke screens, in agreement where necessary with adjacent Sector Controllers.
(e). Issuing executive orders to implement the instructions of the Command Controller and liasing with him,
(f). Liason with other Sector Controllers,
(g). Control of aircraft movements within his sector.
(h). Safety of aircraft under control within his Sector.
(j). The re-inforcement of other sectors as ordered by the Command Controller.

Air Executive:

The Air Executive is responsible to the Sector Controller for:

(a). The execution of his orders on states of readiness.
(b). Diversions to and from the Sectors airfields.
(c). Having displayed on the Tote up-to-date information cocerning:-
  (i). Availability of Sector's fighter forces.
  (ii). The weather state.
  (iii). The state of airfields in the Sector.
(d). Briefing Wing Operations rooms on the current air situation.
(e). When so ordered, passing to airfields, scramble orders including initial vector.
(f). Air/sea rescue.
(g). Liason with Air Executives in adjacent Sectors.

Air Executive Assistant:

To assist the Air Executive in his duties. Directly responsible to the Air Executive for:-

(a). The accuracy of information displayed on the Squadron States and Airfield States Totes.
(b). Maintainance of Air Executive Log.
(c). Forms 'B'. A
(d). Forms 'C'. C

Control Executive

The Control Executive is responsible to the Sector Controller for tactical control of fighters and specifically for:-

(a) Allocating fighters to G.C.I. Stations, and ordering the handover of fighters from one G.C.I. to another.
(b). Allocating V.H.F./R.T. control channels to G.C.I. Stations.
(c). Informing G.C.I. Stations and Sector Fighter Marshals of the orders for control of A.A. guns.
(d). Liason with Chief G.C.I. Controllers in his Sector and the Control Executive of other Sectors.
(e). The safety of aircraft under control.
(f). Informing the Sector Controller of the progress of operations and advising him on the most effective forms of control.

Control Executive Assistant:

Assists the Control Executive in his duties He is directly responsible to the Control Executive for:-

(a) Information displayed on the Mission Tote and Fighter Table.
(b). Maintainance of the Control Executive Log.

Sector Fighter Marshal:

He is responsible to the Sector Controller for:-

(a). Overall control of the Sector Fixer Systems and their employment in accordance with the prevailing circumstances,
(b). The handling of all fighters not under G.C.I. control.
(c). Co-ordination of the work of the Sector Fighter Marshals.
(d). The safety of aircraft under the control of his organisation.

RATS Controller:

Responsible to the Sector Controller for the efficient conduct of Air Defence against RATS. His specific duties are not as yet laid down.

The Sector D.R.W. Officer is responsible to the Command D.R.W. Controller for:-

(a). Implementation of instrictions recieved from the Command D.R.W. Controller.

(b). The provision of all information required by the Command D.R.W. Controller for co-ordination with other sectors.

The Sector D.R.W. Officer is responsible to the Sector Controller for:-

(a). Efficientcy of the Sector D.R.W. organisation.

(b). Implementation of the Controller's decisions in respect of D.R.W.

(c). Interpretation of all D.R.W. information derived from monitoring or the G.S.M..

(d). Advising the Sector Controller on the technical use of D.R.W..

(e). Liason on D.R.W. matters with the D.R.W. staff at Fighter Command and D.R.W. controllers in adjacent Sectors.

(f). Liason with the Control Executive in the allocation of V.H.F. Control channels and high power V.H.F. facilities under conditions of severe jamming.

(g). Liason with the Sector Fighter Marshal in the control and operation of the Sector V.H.F. D/F fixer systems against enemy V.H.F. jamming.

Artillery Controller:

The Artillery Controller is responsible for the efficient control of the H.A.A. and L.A.A. defences in his Sector and for the integration of the into the Sector Air Defence. He is also responsible for:-

(a). Advising the Sector Controller of the part A.A. can take in defence against the enemy threat.

(b). Advising the Sector Controller on the minute-to minute capabilities of the various G.D.A.'s and L.A.A. defences within the Sector.

(c). Implementing the R.A.F. Controllers plan for the integrated Fighter/A.A. battle. This responsibility may be largely discharged through the H.A.A. Executive.

(d). Efficient use of the Sectors L.A.A. defences in accordance with the R.A.F. Controllers plan. This responsobility may be discharged through the L.A.A. Executive.

(e). Liason with the Artillery Controllers in adjacent Sectors.

(f). Liason with and passing information to the War Room of the parent Group(s).

(g). Keeping A.A.D.C.'s informed of those developements in the Air buttle which are likely ti affect them and maintaining close liason with them so as to ensure smooth working between S.O.C. and A.A.O.R.'s.

(h). Ensuring that up-to-date and complete meteorlogical data is regularly transmitted to A.A.O.R.'s.

H.A.A. Executive:

(a) Issuing to appropriate A.A.O.R.'s and A.A. Totes in the S.O.C. and Sector G.C.I.'s, the control orders necessary to implement the Artillery Controllers instructions.

(b). Imposing gun control orders to ensure the safety of fighters when they:-
- (i). are scrambled.
- (ii). are returning to base.
- (iii). are crossing or about to cross a G.D.A..

(c). Relaxing gun restrictions when the reason for them has ended.

(d). Passing sitreps to the A.A.O.R. 's under control of the Sector.

(e). Notifying his Artillery Controller on the state of A.A. defences and the progress of gun engagements within the Sector. 2

(f). Liason with the monitoring officer at C.F.P.. 3.

L.A.A. Executive:-

The L.A.A. Executive is responsible for :-

(a). Alerting A.A. Control Centres in his Sector.

(b). Passing at least one plot on every hostile or doubtful raid which shows a height of less than 10,000 ft and which passes within 40 miles of any "Vital Point" in the Sector.

(c). Keeping L.A.A.C.C.'s informed of the general situation by "sitreps".

(d). Implementing the Artillery Contollers directions on the use of L.A.A. by giving the necessary orders to the L.A.A.C.C.'s in the Sector.

(e). Keeping the Artillery Controller infomed of the capabilities and state of the L.A.A. defences. 3

(f). Relaxing gun restrictions when the reason for them has ended.

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OPERATIONAL REQUIREMENTS OF A G.C.I. STATION AND ITS FUNCTION IN CONTROL

Primary Function of a G.C.I. Station

The primary function of a G.C.I. station within the C. & R. system is:-

(a) To guide friendly fighter aircraft into either visual (by day) or Radar (A.I. Equipment) contact with enemy aircraft with a view to destroying the latter.

(b) To control fighter sweeps should the enemy advance within range of the G.C.I. station's Radar Equipment.

Secondary Function of a G.C.I. Station

The Secondary Function of a G.C.I. Station is:-

(a) To report overland tracks.

(b) To provide primary or seaward coverage according to the type of Radar Equipment available.

(c) To report the activity of surface vessels, when a C.H.E.L. P.P.I. Reporting Tube is available.

NOTE:- Functions (a) and (b) are effected by use of the track telling cabin or C.H.B. (old type) Radar Station.

Operational Requirements

In order that a G.C.I. station may provide maximum efficiency within its defence role it should:-

(a) Be sited w th the intention of utilising the greates seaward coverage attainable by the Radars employed.

(b) Be sited with a view to reducing the effect of P.E.'s to a minimum.

(c) Enjoy a complete Radar coverage over the defended area and its approaches. (See precis on "Essentials of a Radar Station for fuller treatment).

(d) Possess an efficient method of communication with airborne fighters.

(e) Continuously operate through Radar and Radio interference, i.e. It should possess effective anti-jamming devices.

(f) Strive to maintain continuity with airborne fighters despite enemy "Saturation" Tactics.

(g) Posses I.F.F. Equipment to facilitate distiction between friendly and hostile aircraft.

(h) Possess accurate height finding facilities.

(i) Possess efficient liaison between parent S.O.C. and adjacent G.C.I, Stations.

(j) Provide for the expiditious forwarding of information regarding aircraft in distress through the usual channels to the organisation responsible for Air Sea Rescue Operations.

G.C.I. (INTERCEPT) CABIN CREW DUTIES

The crew consits of:-

(a) Intercept Controller (an officer)
(b) N.C.O. i/c watch (cabin supervisor)
(c) P.P.I. reader or tracker
(d) H/Range reader
(e) Azicator operator
(f) D/R navigator
(g) Tracer or recorder

(a) Intercept Controller

He/She is to:-

(a) Carry out all interceptions on target determined by the Chief Controller with fighters allocated by the same source.

(b) Maintain watch on the R/T frequency ordered by the Chief Controller

(c) Use correct R/T procedures and code words as laid down in A.C.P'S. 165 and 125A.

(d) Use for interception work, the type of control ordered by the Chief Controller (i.e. close, loose, loose-close, freelance or broadcast).

(e) Be responsible for the tracing of the personnel in the intercept cabin.

(f) Remain in his intercept cabin until permitted to stand down by the Chief Controller.

(g) Ensure the safety of aircraft under his control at all times by all means at his command, keeping the Chief Controller briefed as to the endurance (fuel position) of each aircraft.

(h) Ensure that all equipment in his cabin is working efficiently at all times, ordering checks of such equipment from time to time when operations permit.

(j) Ensure that faults detected are reported through the correct channels, and that remedial action is taken.

(k) Detail to the P.P.I. Tracker (reader) the responses to be plotted.

(l) Draw the attention of the Chief Controller to any track which by its behaviour, appears to be suspect or carrying out emergency procedure.

(m) Ensure that all reports and tracings which are unnecessary are prepared.

(n) Ensure that plotting, telling, height reading, recording and D/R navigation are in conformity with practices laid in F.C. C. & R. Procedure Instructions, and any local orders which may be issued from time to time.

(p) Keep himself fully acquainted with Controllers Orders by checking them once on each watch.

(q) Keep himself fully acquainted with No. 11 Group Air Staff Instructions and C. & R. Procedure Instructions by checking them at least once per month.

(r) Carry out lectures for which he has been detailed by the

Chief Controller and/or Flight Training Officer.

N.C.O. i/c Watch (Cabin Supervisor)

He/She is to:-

(a) Be responsible for the highest state of cleanliness in the cabin at all times.

(b) Be responsible for the high standard of training discipline and efficiency within his/her cabin at all times.

(c) Ensure that his/her cabin is manned in accordance with the requirements of the Chief Controller.

(d) Ensure that all information and Met. Boards are up to date at all times.

(e) Ensure that there is within the cabin sufficient:-

(i) Interception records
(ii) Control records
(iii) Appendix reports
(iv) Tracing sheets
(v) Chinograph and coloured pencils

(f) Maintain the Cabin Log accurately and neatly.

(g) Check all lines of communication to ensure their serviceability.

(h) Warn the Controller at frequent intervals the actual time an aircraft has been airborne. This is of supreme importance in the case of jet aircraft.

(j) Ensure that all members of the crew discharge their duties correctly and efficiently.

(k) Ensure that personnel are relieved at intervals to obviate fatigue.

(l) Keep the noise within the cabin down to a minimum.

(m) Answer the P.A.X. phone.

P.P.I. Reader (Tracker)

He/She is to:-

(a) Ensure that he/she is in direct communication with the following prior to the commencements of operations:-

(i) Fighter Table
(ii) D/R Navigator
(iii) Tracer or Recorder
(iv) Height Range Reader

(b) Pass to the Fighter Table plotter the following information when known:-

(i) Call sign of Fighter
(ii) Identification of target, except where P/I's are being performed, in which case the callsign of the Fighter acting as Target to be passed.

(iii) Strength of Fighter Force
(iv) Height of Fighters every time a change in altitude occurs.
(v) R/T Channel number.
(vi) Grid reference and direction of each plot, to nearest cardinal or quadrantal point.

(c) Pass any changes of information immediately they occur.

(d) Warn D/R Navigator when plot is fading by means of words "FADE ONE"------- "FADE TWO"-------- "FADE THREE" for the three successive sweeps of the trace. He/she is then to remain silent to allow the D/R Navigator to pass D/R plots. He/she is to signify the re-appearance of the plot by the words -------- "Reappeared in"------- and then to continue normal plotting procedure.

(e) Plot only those aircraft which he/she is instructed to pplot by the Interception Controller.

(f) Follow the Controller in his switching of aerials in order that he may have constant height of the aircraft.

(g) Azicate the Type 13 correctly to allow the Height Reader to obtain heights.

(h) To strobe the equipment correctly to allow the Type 7 Height/Range Operator to obtain heights.

Height/Range Operator

He/She is to:-

(a) Ensure that the aerial selector switch is in the "NORMAL" position and that he is obtaining a "split" response, set to personal taste, at the beginning of operations.

(b) Calculate heights from the strobed range received from the P.P.I. Reader (Tracker) on aircraft under observation.

(c) Pass heights, preferably relative heights, and in any subsequent changes in altitude to the Controllers.

(d) Check heights continuously.

Type 13 Operator

(a) Obtain heights on aircraft indicated by Tracker.

(b) Pass relative heights unless absolute heights are called for by the Controller.

Azicator Operator

He/She combines the function of P.P.I. Reader and Azicator Operator.

D/R Navigator

He/She is to:-

(a) Ensure that he is in clear contact with the Tracker, Tracer/Recorder and Fighter Table.

(b) Ensure that all his equipment is working in satisfactory fashion and set up correctly.

(c) Determine the aircrafts BASE and find height at which it will operate. He is to bring to the Controller's notice any hazards (firing ranges, balloons etc.) which will affect his aircrafts safety.

(d) Work continuously from the INSTANT of commencement of an interception on the HEADING and SPEED of the Target aircraft, obtaining this information and any change in such information in the shortest possible time compatible with accuracy and passing them clearly to the Controller.

(e) Maintain continuous D/R plots on both Fighter and Target and pass D/R plots to the Fighter Table, Tracer/Recorder and controller immediately the words "Fade Three" are heard from the Tracker. He is to continue passing such plots until the Tracker is heard to pass a reappearance plot on both aircraft.

(f) Calculate "PIGEONS" at the conclusion of each P/I and to pass the information to the Controller.

(g) Carry out "Exercise Tempects" and other wind-finding exercises.

(h) Compute "SNAP" headings and speeds in four plots for the Controller's information, substantiated by corrected version after same six or seven plots.

Tracer/Recorder

He/She is to:-

(a) Ensure that he is in clear contact with the Tracker and D/R Navigator.

(b) Ensure that if tracing, he/she has sufficient tracing sheets for use and if recording, that sufficient operational Research Recording Sheets are available.

(c) If tracing, to show by means of different coloured pencils the tracks of both fighter and target together with the following information:-

(i) Controller's name
(ii) Number of Run
(iii) Fighter callsign
(iv) Targets callsign or identification
(v) Tracks with plots oriotated with time and direction
(vi) Fighter and Target height
(vii) TALLY-HO'S, CONTACTS? JUDIES, MURDERS and RUNS ABANDONED with relevant time
(viii) Time and plot when over to local frequency when applicable.

(d) Pass completed tracings to cabin supervisor.

(e) If recording, to show all information called for in paragraph (c) in the recording sheets.

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DUTIES OF PERSONNEL AT THE C.F.P.

1. Filter Controller

(a) Is responsible to the Sector Commander for the efficient control of operations at his C.F.P.

(b) Ensures that the resources of the associated reporting radar stations and R.O.C. Centres are fully and correctly utilized in order to produce a clear and up-to-date picture of all air activity in his designated area of responsibility.

(c) Ensures that all air information is broadcast to all users with the minimum delay and loss.

(d) Is responsible for ordering Area Raid Reporting when in his opinion a clearer picture of the prevailing air activity can be provided by this method.

(e) Allocates areas of responsibility to the Filter Supervisors in accordance with prevailing conditions.

(f) Ensures that all movements are made available by the Raid Recognition Section efficiently and rapidly.

(g) Effects liaison with Filter Controllers at adjacent C.F.Ps. when it is necessary to decide responsibility for reporting raids which overlap more than one C.F.P. area.

(h) Maintains efficient liaison with:-

- (i) R.O.C. Liaison Officer
- (ii) A.A. Monitoring Officer
- (iii) A.R.W. Liaison Officer

(j) Attempts to interpret the air activity in terms of threats which may be reported by area raid techniques even though individual tracking may be possible. Stream attacks need not necessary be displayed as a single area. In the case of very narrow streams, individual raid techniques may be employed. Grouping aircraft is advisable for individual raid plaques.

(k) Ensures that all tracks are identified with the minimum delay by the Raid Recognition Officer.

(L) Allots plotting areas to individual C.H. stations reporting to his C.F.P., on the basis that "C.H. Stations will plot from infinity inwards to the practical maximum range of Type 7 radars". The minor invisible boundaries will naturally vary from time to time in accordance with the air situation and performance of Type 7 radars.

2. Filter Officer The Filter Officer is responsible to the Filter Controller and his duties are:-

(a) To ensure that all Reporting sources maintain maximum operational efficiency by maintaining the closest liaison with Station Supervisors.

(b) To ensure that all instructions to Reporting sources issued by the Filter Controller are conveyed to them with the minimum delay.

(c) To maintain close liaison with the G.P.O. and to ensure that all landline faults are dealt with expeditiously.

(d) To ensure that time checks are passed to all stations at least once per watch.

(e) To investigate all reports of unserviceability or restrictions on operational efficiency and ensure that all remedial action is being taken.

(f) To ensure that the closest liaison is maintained with adjacent D.F.Ps. when large scale activity is passing from one C.F.P. to another.

(g) To inform all users should broadcast areas be changed to meet variations in the intensity of activity.

(h) To ensure that Tellers comply strictly with Telling Procedures at all times.

(j) To maintain constant close surveillance of the track production area, and by liaison with station supervisors, he endeavours to maintain continuity of tracking, height and strength information by directing stations on to raids entering their areas of coverage and by altering action. In so soing, he attempts to anticipate the requirements of Filter Supervisors so that as far as possible a constant flow of information is maintained upon priority tracks and frequent queries are thus avoided.

3. Filter Supervisor The Filter Supervisor is responsible directly to the Filter Controller and his duties are:-

(a) To correlate all radar and/or R.O.C. information within his area of responsibility.

(b) To produce an accurate up-to-date filtered air picture from incoming information by giving due weight to station performances.

(c) To judge the most efficient way of utilizing the reporting resources and ensure that an even flow of information is made available to him.

(d) To ensure that new tracks are pointed out to the Teller concerned.

(e) To filter tracks in rotation in a clockwise direction unless otherwise ordered by the Filter Controller.

(f) To make appropriate Tellers aware of faded tracks by holding up the raid plaque before removing it from the table.

(g) To ensure that serial numbers and designations are told to reporting sources by the Filter Centre Plotter, e.g. Track Seven now Serial Three Four Two, or Serial Three Four Fife now Hostile Three Four Fife.

(h) To pass special request for information to stations via the Filter Officer and not over the plotting line in order to prevent disruption of the inboard information flow. Suppression may be passed via the plotting line, but in general principle C.F.P. plotters should be suppressed rather than the station P.P.I. observer when too much information is being received upon any track.

(j) To ensure that the following Filter Procedures are maintained at all times:-

Filter Procedures

(a) The initial filtered position of a track is displayed by a halma coloured in accordance with the colour change clock. Where a direction is given with the first plot, the filtered position is displayed by a halma and a heart shaped arrow. The first two arrows are white.

(b) A serial number is allotted to each new track. This is done by calling for the next plaque from the Raid Orderly, at the same time indicating the ancillary information e.g. Next Serial - One at ten (the plaque is placed adjacent to the halma in such a position that it is easily readable by the Teller concerned).

(c) Subsequent filtered positions are denoted by coloured arrows, the colours are used in order to facilitate discrimination of tracks in close proximity.

YELLOW FOR FIGHTERS.

(d) Heights are filtered to the nearest even 1,000 ft. e.g. 2, 4, 6, 8, etc., except where the station plotter displays 1 estimated (see precis "Rats at C.F.P.").

(e) Changes of ancillary information are denoted by a heart shaped arrow contrasting in colour to the tracking arrows.

F28³ x F27³ = F27 .06.

(f) Where two or more tracks with the same identification merge the track so formed is given the designation of the track which has the greater number of aircraft, or if all tracks have the same strength the lowest serial number is retained on the merged track.

(g) When Hostile or X raids merge with Fighter Tracks, the serial number of the Hostile or X raid track is retained with the prefix M for mix-up. When such tracks subsequently split new serial numbers with the prefix X for x-raid are to be allocated until identified by the Recognition Officer.

(h) When a track splits other than as detailed in (g) above, one part is continued with the original designation and new serial numbers allocated to the other portions.

(j) The Filter Controller's attention is drawn to the original designation in case a change of the original identification is deemed necessary.

(k) Upon a change of ancillary information, the Raid Orderly is notified and the new information displayed on the plaque. The information removed from the plaque is placed above the plaque and remains there until normal filter arrows are substituted for the heart shaped arrow denoting the change.

(L) In order to present a clear but comprehensive picture not more than three filter arrows remain on any one track, although under normal activity not less than this number should remain.

(m) Upon removal of tracks, Raid Plaques are placed in the Raid Removal Tray in the correct colour section.

(n) Should it be necessary to re-position a track, a heart shaped arrow is used for this purpose and the Teller made aware of the change.

(p) Where "F" is placed by the plotter against a track which has not yet been allotted a serial number, or on the tail of the raid plaque of a filtered track the Filter Supervisor will:-

- (i) Place "F" identification on any unidentified or friendly raid plaque associated with the track upon his own authority.
- (ii) If the associated track is identified as H. or X. he changes to "F" identification only with the acknowledgement of the Filter Controller.

4. Recognition Officer

(a) Is responsible to the Filter Controller for the efficient operation of the Raid Recognition Section.

(b) Identifies all tracks as soon as possible after their appearance on the C.F.P. Tables by the use of movement information from A.T.C.C.s, presence of I.F.F., track behaviour and any other means at his disposal.

(c) Indicates the identification to the tables by use of the projection lamp.

(d) Prefixes with the letter X or H tracks on which no movement information is available or which by their behaviour or by intelligence reports which cause them to be suspect.

(e) To effect close liaison with the R.O.C.L.O. for visual identification of tracks reported from R.O.C. sources.

(f) To effect close liaison with the Filter Officer for station visual identification or abnormal track behaviour.

(g) Is fully conversant with station performance figures as an aid to rapid and accurate assessment of track behaviour.

(h) Effects liaison with Recognition Officers at adjacent C.F.Ps. in order to facilitate identification of unidentified tracks passing from one area to another.

(j) The circuit to the S.O.C. Fighter Identification Teller is used for general liaison regarding Fighter Information and for intermittant checks of tracks identified by reporting sources as close controlled fighters.

5. <u>N.C.O. i/c Watch</u>

(a) Is responsible to the Filter Controller for the efficient working of all C.F.P. plotters and tellers.

(b) Effects regular relief and changeover of plotters and tellers.

(c) Is responsible for the training of all crew members in every aspect of their duties.

(d) Checks that his crew adhere to procedure instructions at all times.

(e) Monitors and checks plotting and telling lines periodically in order to ensure that procedure instructions are adhered to.

(f) Maintains a watch log detailing the duties of all personnel throughout the watch and noting any unusual occurrences.

(g) Reports all unserviceable equipment to, and obtains replacements from, the Floor Supervisor.

6. <u>Floor Supervisor</u>

(a) Is responsible to the Filter Controller for the efficiency and discipline of all C.F.P. crew members.

(b) Checks all operational lines prior to the commencement of the watch.

(c) Is responsible for the control of the changeover panel, patching of lines and distribution of broadcast upon instructions from the Filter Controller and/or Filter Officer.

(d) Ensures that all equipment in the C.F.P. is in a serviceable condition and arranges for the distribution of replacements.

(e) Effects liaison with the G.P.O. engineer in order to ensure maintainance of serviceability of G.P.O. equipment.

(f) Maintains a log showing the following details:-

(i) Instructions issued during his tour of duty by the Filter Controller and Filter Officer.
(ii) Details of breakdowns and unserviceability which affect the efficiency of the C.F.P. and remedial action taken.

7. The Plotter

(a) Is connected by land line to the teller at the reporting source. The line may be shared by two plotters when the activity is beyond the capacity of a single plotter.

(b) Is responsible to the Filter Supervisor for plotting accurately using the correct equipment, all information falling in his area of responsibility which is passed to him from the reporting source.

(c) Checks the serviceability of the line immediately upon taking over the duties.

(d) Uses the appropriate equipment (see precis C.F.P. Equipment).

(e) Removes all ancillary information counters when this information has been filtered and is displayed on a raid plaque.

(f) Places a track number counter on each track in accordance with the last diget of track serial number whenever a plot on the track is passed.

(g) Passes to the reporting source the serial number of each track immediately it is allocated by the Filter Supervisor and the identification as soon as it is available.

(h) Passes all instructions and requests issued by the Filter Supervisor without delay.

(j) Passes the raid plaque and associated equipment together with the new plan position counter to the adjacent table when his area of responsibility covers more than one table and a track passes from one table to the next, and draws the Filter Supervisor's attention to the track.

(k) Remains seated whenever possible and returns to this position after placing a plot which necessitates standing.

(L) Places a "faded Plaque" on the last plan position when told a track has faded.

(m) Places an I.F.F. counter beside the latest plot when I.F.F. is reported and removes this counter as soon as this information is displayed on the raid plaque.

(n) Maintains a clear picture by removing unwanted counters without delay.

(p) Places an "F" plaque of the station colour against any track told from the reporting sources as a Fighter track.

(q) Places a height symbol of 1E. against plots notified as "RAMS" from the reporting source.

(r) When information has been missed or not clearly understood the procedure is "Repeat -------- (whichever part has been missed)

e.g. (i) Repeat Height
(ii) Repeat Track No.

8. The Teller

(a) Is positioned on the balcony overlooking the C.F.P. table/s covering his area of responsibility.

(b) Tells all filtered information in his area. Tracks are told methodically working in a clockwise direction except as follows:-

- (i) New Tracks as indicated by the Filter Supervisor are told immediately.
- (ii) When instructed by the Filter Officer to concentrate on specific tracks.
- (iii) When the following priority are in force under high activity conditions
  - (a) New Tracks
  - (b) Unidentified Tracks
  - (c) Hostiles
  - (d) Other Tracks
- (iv) Fighter Tracks are normally told only at the request of S.O.C.

N U H O

(c) Tells steadily and clearly to enable broadcast plotters to work at maximum efficiency.

(d) Tells ancillary information with the first two filtered psotions and thereafter upon change only. This does not apply to jamming indicators which are repeated with each broadcast of the track position.

(e) Tells orbitting plots as two figure reference.

(f) Does not tell information which falls in the overlap area adjacent to his area of responsibility.

(g) In quiet periods or whenever possible summarises the track situation as displayed on the C.F.P. tables in the following form:-

"SUMMARY, SUMMARY. There remains - Three Hostiles - One Two Three - One Two Four and One Two Five, One Raid - One Two Nine - One Serial - One Three Six, Two Friendlies - One Three Zero - One Three Seven".

9. The Recorder

(a) Monitors the telling line as detailed by the Floor Supervisor.

(b) Records (in single copy) all information passed on the line being monitored.

(c) Records the time to the nearest six seconds beside each set of information.

(d) Heads each recording sheet with date, station name, page number and recorders name.

(e) Notes any special instructions, occurences or change of broadcast network in the Remarks column.

D- S- P- R-
Dear Sir Please Return

(f) Uses the following symbols:-

P.A.	-	Out of C.F.P. area			
D.	-	Faded			
R.	-	Re-appeared			
R.I.	-	Re-identified			
R.P.	-	Re-positioned			
O	-	Orbitting			
N.H.	-	No Height			
A.R.	-	Area Raid			
G.W.	-	Green Window	R.W.	-	Red Window

10. Raid Orderly

(a) Is responsible to the Filter Supervisor for the quick and efficient production of assembled raid plaques.

(b) Maintains strict sequence of serial numbers when issuing plaques.

(c) Removes raid plaques from the Raid Removal Tray.

(d) Collects and stores all filter equipment discarded by the Filter Supervisor.

(e) Ensures that an adequate supply of filter equipment is available to the Filter Supervisor at all times.

(f) Issues D.R.W. plaques on request.

11. Speed Orderly

See appropriate Precis.

F & H of X.

= Serial of H or X
+ Mix-up.

X New serial / New Serials

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THE FIGHTER COMMAND V.H.F. FIXER ORGANIZATION

PURPOSE

1. V.H.F. Fixer Systems in General

(a) A V.H.F. fixer system is a means whereby the position of an airborne aircraft can be determined by ground stations, with varying degrees of accuracy, from V.H.F. transmissions made by the aircraft.

(b) To be effective the technique requires the co-operation of the aircraft's crew.

2. The Fighter Command Organization The Fighter Command V.H.F. fixer organization is maintained for the following reasons:-

(a) To assist interception controllers and fighter marshals by providing a means, alternative to radar, of determining (with varying degrees of accuracy) the positions of fighter aircraft when airborne.

(b) To assist interception controllers and fighter marshals by providing a means, alternative to the use of "canary", of determining which response of (perhaps) many on a radar display is produced by the aircraft under control. The controller relates the "fixed" position to that of a particular response.

(c) To serve as a navigational aid for fighter pilots.

COMPOSITION

3. Each Fighter Sector operates one or more V.H.F. fixer systems, the number being sufficient both:-

(a) To provide complete cover at heights above 2,000 feet over the entire Sector and to seaward as far as is practicable; and

(b) to handle the anticipated activity.

4. A typical system comprises:-

(a) D/F Stations. From three to six in number, perhaps 40 miles apart being grouped in a cluster, not disposed in a line. A D/F station is capable of determining (with varying accuracy) the azimuthal bearing from which it receives a radio transmission.

(b) A Triangulation Centre. When an aircraft's transmission is heard, of sufficient strength and duration for bearing-determination the D/F stations pass their bearings to the system's triangulation centre. Here the bearings can be plotted on a chart-table so as to disclose, by their common intersection, the position of the aircraft (the purpose being known as "triangulation").

5. All the D/F stations in any one fixer system use a common frequency, but no two systems (normally) use the same. The frequency is allocated to a sector fighter marshal and all communication between air and ground in connection with fixing is handled by him.

6. The triangulation centres for each of a Sector's systems are (usually) all located within a single room in the S.O.C.

THE V.H.F. D/F STATION

7. Equipment

(a) Consists essentially of a V.H.F. receiver fed from a horizontally rotatable, highly directional, aerail array.

(b) The aerial is hand-rotated, its orientation being indicated to the operator by a calibrated dial incorporated in the turning mechanism.

(c) The aerial array comprises two vertical dipoles backed by two similar dipoles which act as reflectors (see Fig. 1).

(d) If the aerial is rotated while a transmission is being received, the signal heard by the operator will steadily vary in intensity. Whenever the plane of the receiver-dipoles points towards the transmitting aircraft (i.e. twice in every 360 degrees rotation), the signal will be heard the most strongly (a "maximum"); whenever it is perpendicular to that direction, the signal will be heard the most weakly (a "minimum"). Through the intervening positions signal strength will steadily increase or decrease, as the case may be.

(e) By means of a "sense plate" attached to the aerial turning wheel, the operator can readily "switch-out" (i.e. render inoperative) the two reflector-dipoles. The reason for incorporating this feature will become apparent in the following paragraph.

(f) Two receivers are normally installed at each D/F station and the aerial can be instantly switched from one to the other. This permits the station to change to a second frequency with great rapidity.

8. Operation

(a) The station can be operated by a single person. Normally, however, there are two operators on each watch.

(b) To determine the bearing of a transmitting aircraft, the operator rotates his aerial until he receives a minimum signal. (The ear can determine a minimum more precisely than it can a maximum). The plane of the receiver-dipoles must now be perpendicular to the direction of the aircraft (paragraph 7(d)).

(c) The turning-gear dial (paragraph 7 (b)) is calibrated, however, to indicate not the actual "lie" of the receiver-dipole, but a direction at right angles - i.e. either the bearing of the aircraft or its reciprocal.

(d) To determine which, the operator turns the aerial just sufficiently off the minimum to secure an audible signal; switches-out the reflectors by lifting the sense plate (paragraph 7(e)); and notes whether the signal is thereby decreased or increased. If decreased, the bearing indicated was the required one; if increased, it was the reciprocal.

(e) The operator is required to pass to the triangulation centre the true (not magnetic) bearing of the aircraft.

9. Classification of D/F Bearings. The precision with which the D/F operator can determine a minimum signal depends on many factors - notably on the position and height of the aircraft transmitting. Bearings are therefore classified, the classifications being:-

1st class bearing: one which the D/F operator may reasonably consider to be accurate within plus or minus 2 degrees.

2nd class bearing: one which the D/F operator may reasonably consider to be accurate only within plus or minus 5 degrees.

3rd class bearing: one which the D/F operator may reasonably consider to be accurate only within plus or minus 10 degrees.

If the operator does not consider his bearing to be accurate within plus or minus 10 degrees, he passes "no bearing".

THE TRIANGULATION CENTRE

10. The Triangulation Table

(a) The table on which the bearings are plotted carries a horizontal map of the area served by the system.

(b) From a hole at the location of each D/F station, as shown on the map, emerges a ring which is attached to a weight cord passing through the table.

(c) Around each hole is displayed a compass-rose indicating true bearings.

11. Display of Bearings

(a) Triangulation plotters are disposed around the table, one for each of the contributing D/F stations.

(b) Each plotter is in continous, direct, telephonic communication with his associated D/F operator.

(c) The D/F operator, on determining a bearing, passes (i) the aircraft callsign (ii) the classification of the bearing and (iii) the bearing, to the plotter.

(d) If the bearing is first class, the plotter displays it, using the ringed cord in conjunction with the appropriate compass-rose, and repeats aloud the aircraft call-sign.

(e) If the bearing is second or third class, the plotter will await the triangulation teller's (see para. 16(c)) demand before displaying it and announcing the aircraft call-sign.

12. The Triangulation Teller

(a) Because the bearings are generally - to the extent indicated in para. 9 - inaccurate, it is most unlikely that they will intersect in a common point. Normally, their several intersections are spread over a small area.

(b) A decision has, therefore, to be made: which point in this area is to be taken as the position of the aircraft?

(c) An experienced fighter plotter, known as the triangulation teller, is invested with the responsibility for:-

- (i) choosing the position (see para. 16)
- (ii) classigying its accuracy (see para. 17)
- (iii) passing position and classification to the user (see para. 23)
- (iv) supervising triangulation generally.

13. The Triangulation Recorder The triangulation recorder maintains a record of each fix passed by the triangulation teller, noting:-

- (a) call-sign of the aircraft concerned
- (b) grid-reference of the "fixed" position
- (c) class of fix
- (d) time at which the fix is passed to the user.

Nudist Red C.G 1249 'A' 0900 hrs.

TRIANGULATION

14. Basic Principle. Given a number of bearings (generally of various classes), all appertaining to the same aircraft and taken simultaneously, the process of fixing the aircraft from first principles would clearly be:-

(a) To visualize the 2 degrees (first class), 5 degrees (second class) or 10 degrees (third class) limits either side of each bearing, as appropriate to its class. That is, to see "bearing-zones" rather than bearing-lines.

(b) To visualize the single, small, area common to all bearing-zones (see Fig. 2).

(c) The centre of this area would then be the position best chosen as the fix.

(d) The distance of the corner of the area furthest from the chosen position would represent the probable maximum error in fixing.

15. Practice. Speed is all-important in fixing. If a minute is allowed to elapse between bearing-measurement at the D/F stations and the receipt of the resultant fix by the user, the aircraft may well have travelled 10 miles or more in the meantime. It is therefore necessary for the whole triangulation process to be conducted without the slightest hesitancy and with some simplification of the procedure set forth in para. 14.

16. Triangulation Teller: Sequence of Actions. In fixing an aircraft, the triangulation teller must pursue the following sequence:-

(a) Ensure that all bearings appertain to the same aircraft.

(b) The triangulation plotter, in the first instance, displays only first class bearings (para.11). If there are at least three significant bearings among them, accept the centre of the area they enclose as the fix.

(c) If not, call for "seconds" (second-class bearings). If[x] there is now a total of at least three significant bearings, select the fix in accordance with para. 11.

NOTE: [x] Significant bearings:-

(a) Where two bearings are within 20 degrees of parallelism, they are only to be counted as one, significant, bearing.

(b) Bearings wrongly determined or wrongly plotted have, of course, no significance. The triangulation teller must be alert to detect manifest errors. D/F operators occasionally (although without justification) confuse bearing and reciprocal and, unwittingly, pass the latter. Again misunderstanding may occur between D/F operator and plotter (e.g. a bearing of 251 degrees may be displayed as 291 degrees).

(c) If there are still fewer than three significant bearings, call for "thirds" (third class bearings). Select the fix in accordance with para. 14.

(d) Classify the fix according to the standards of para. 17.

(e) Pass the fix and its classification to the users (see para. 23).

17. Classification of Fixes. Fixes are classified by the following standards:-

A Class One which the teller may reasonably consider to be accurate within 5 nautical miles.

B Class One which the teller may reasonably consider to be accurate only within 20 nautical miles.

C Class One which the teller may reasonably consider to be accurate only within 50 nautical miles.

18. Classifying the Fix While fixes will, in principle, be classified in accordance with paras. 14 (d) and 17, the triangulation teller may safely consider any ~~fix as Class A if it is derived from three significant bearings of which as least two are first class.~~ OK.

PROCEDURE BY WHICH A FIX IS CALLED FOR

19. Fix Required by Sector Fighter Marshal The Sector Fighter Marshal normally controls exclusively on his fixer frequency so that, when he requires a position from the triangulation teller, he has only to instruct the formation leader to make a transmission of suitable length (see para. 22).

20. Fix Required by an Interception Controller

(a) Interception controllers rarely, if ever, control on a sector fixer frequency.

(b) The Controller therefore orders the pilot to "go over" to the appropriate fixer frequency, to "transmit for fix", and forthwith to return to the control frequency.

(c) No warning need be given by the interception controller before utilizing a fixer system in this way. The D/F stations have only to hear the aircraft transmit specifically for a fix to take action. Indeed, fixer systems fix any transmission of suitable length, whether or not fixing is asked for, if the aircraft callsign is given.

21. Fix Required by a Pilot A fighter pilot, requiring a fix for his own assistance, may call the appropriate sector fighter marshal requesting that a fix be taken and passed to him (th pilot) by R/T.

ACTION TAKEN BY A PILOT WHEN TRANSMITTING FOR A FIX

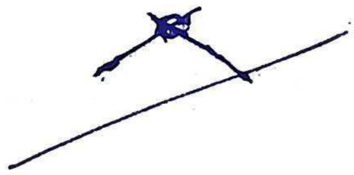
22. When a fix is required, the pilot transmits (on the appropriate Sector Fixer Frequency) for at least 10 seconds, prefixing his transmission with the callsign of the sector fighter marshal followed by his own. The 10 second transmission in war-time usually consists of carrier-wave alone (that is, the pilot continues to depress his transmitter switch without speaking), or of a repetition of the pilot's callsign. In peacetime it is more commonly occupied by the pilot passing his course, height and airspeed. The 10 second period is the shortest time in which a D/F operator can locate a minimum signal and "sense" it.

PASSAGE OF FIXES FROM THE TRIANGULATION TELLER TO USER

23. The triangulation teller passes fixes to users over a landline-broadcast system. He is equipped with a head-and-breast set to this end.

Bearings first

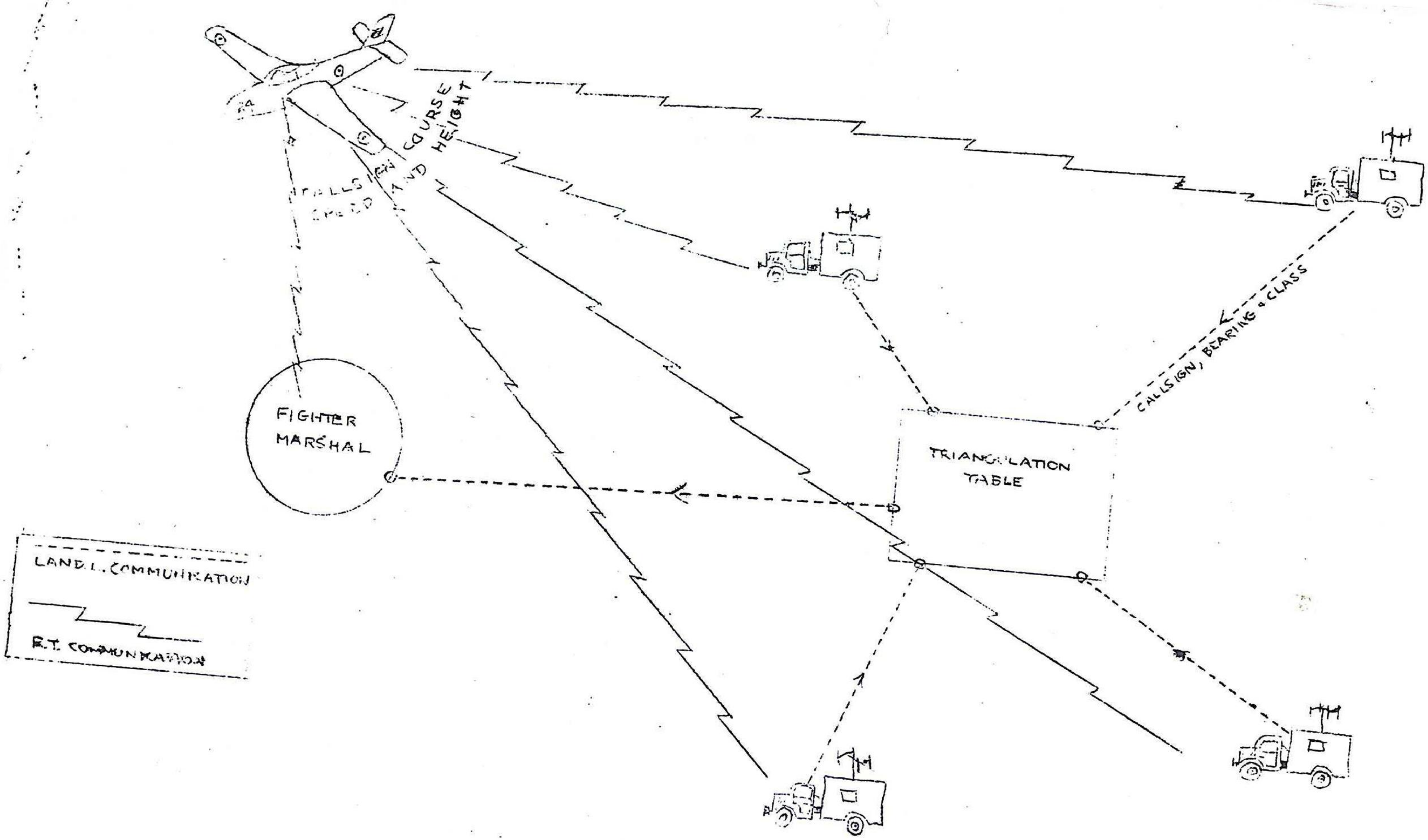
2 1st class at 90° can give A ~~1st class~~ fix.



Bearing 1st – within + or – 2°
2nd – " " " " 5°
3rd – " " " " 10°

Fixes. A – within 5 N. miles
B – " 20 " "
C – 50 " "

Told –
Callsign Grid Reference. Class of fix & time passed.


CALLSIGN COURSE
SPEED AND HEIGHT
FIGHTER MARSHAL
TRIANGULATION TABLE
CALLSIGN, BEARING & CLASS
LAND L. COMMUNICATION
R.T. COMMUNICATION

V. H. F. D/F

MOVEMENT LIASON'S ORGANISATION AND RAID RECOGNITION OFFICER

The British Isles and the surrounding seas are divided for Air Traffic Control purposes into a number of regions known as Flight Information Regions (F.I.R.'s) within each of which all Air Traffic Control activities are directed from an Air Traffic Control Centre (A.T.C.C.)

There are at present four F.I.R.'s. Scottish, Northern, South Western and South Eastern.

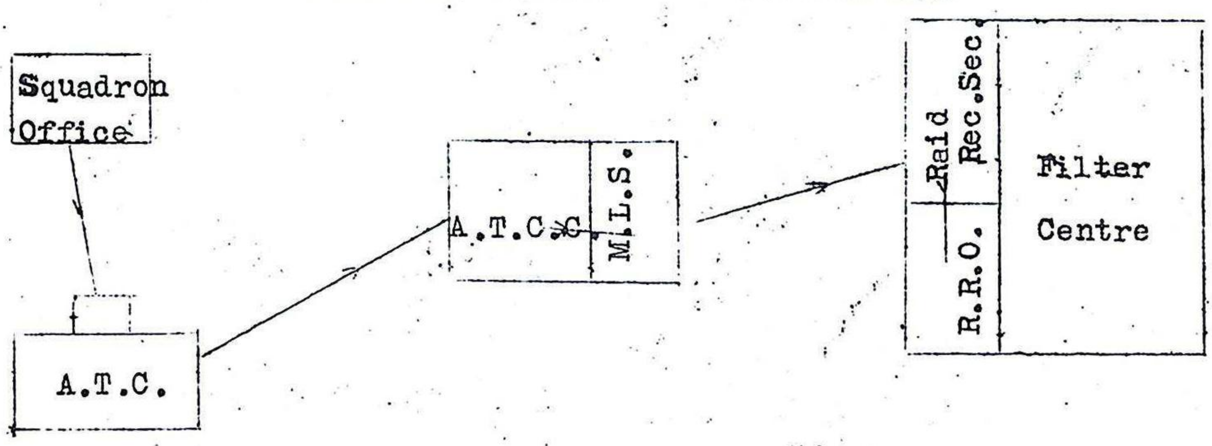
The A.T.C.C.'s are situated at:-

Prestwick	-	Scottish F.I.R.
Preston	-	North F.I.R.
Gloucester	-	South Western F.I.R.
Uxbridge	-	South Eastern F.I.R.

A sub-centre to Preston is established at Watnall solely for R.A.F. traffic. Prestwick, Preston and Uxbridge A.T.C.C.'s are manned by joint civil and R.A.F. staffs. Gloucester and Watnall wholly by R.A.F. personnel. Uxbridge accepts direct responsibility for the control of civil traffic in the South Western F,I.R., but co-operates very closely with Gloucester.

Each of these A.T.C.C.'s provide a "Movement Liaison Section" (M.L.S.) which forward aircraft movements to the appropriate filter centre to assist in the identification of tracks.

PASSAGE OF NOTIFICATION OF MOVEMENTS



At the filter centre the movements are received by the Raid Recognition Section who prepare movement sheets for the use of the Raid Recognition Officer.

These movements are received by either:-

(a) Teleprinter, which is normally used to receive pre-flight information, or
(b) Direct Teleprinter, which is used when last minute changes to flight plans are made, or diversions become necessary.

Movement Forms

The forms used by the raid recognition section are:-

(1) Movement Liaison Message Form Movements received from A.T.C.C.'s are entered in the log book and copied onto M.L. message forms. Each message form may be used for "Incoming", "Outgoing" or "Internal" movements. Thus a completed M.L. message form would show the following

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FROM: (Point of Departure)	TO: (Destination)
A. M.L. Track no.	(A.T.C.C. Reference Number)
B. Quantity	(No. of aircraft involved)
C. A/c Type	(e.g. Hastings, Lincolns)
D. Height	(The height at which certain places, e.g. the coastline, are expected to be passed)
E. Speed (knots)	
F. Time G. Georef	(Time and position either: 1. Incoming- when crossing an arbitary line relating to the limits of reporting cover or, 2. Outgoing- when crossing out over U.K. coast.)
H. Time J. Georef	(Time and position when halfway between the arbitary line referred to in para 1. above and the coast.
K. Time L. Georef	(1. Incoming- when crossing the U.K. coast, or 2. Outgoing- when crossing the arbitary line referred to in para 1(G) above
T.O.	(Time of origin of message at A.T.C.C. e.g.100900Z

(2) Movement Sheet This is a perspex covered chart upon which are entered the details from the message form. The sheet shows:-

(1) A map of the U.K. and approaches.
(11) Georef graticules - lettering around the edges of the chart.
(111) Degrees of latitude and longitude.
(1V) The arbitary line relating to the limits of reporting cover.
(V) Main airfields marked in letter code.

(3) Naval Weekly Practice Sheet The R.R.O. is provided with a weekly programme of projected flying to be carried out by naval aircraft stationed within the sector area. This sheet shows:-

(1) Naval bases and seaward approaches.
(11) Lettered zones (not georef).
(111) Naval flying practices scheduled for each day (e.g. torpedo attacks, air to air firing, target towing for naval A.A. practices etc.)

Procedure

(1) Movements received from the A.T.C.C. by teleprinter are frequently copied directly onto a movement sheet and entered in the log. Movements received by telephone are taken down on a M.L. message form, copied onto a movement sheet and entered in the log.

(2) The movement sheet is compiled and placed (in chronological order with other sheets) in fromt of the R.R.O.

(3) The R.R.O. checks the movements and is able to recognise tracks as they appear on the C.C.F.P. tables from the details in the M.L. sheets. The majority of R.R.O. decisions result, directly or indirectly, from Movement sheet information.

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SEARCH AND RESCUE

Organisation

The Search and Rescue organisation in the United Kingdom is operated jointly by the R.A.F. and the Royal Navy under the co-ordinating direction of Coastal Command. Broadly speaking, the R.A.F. is responsible for search, the dropping of survival equipment, and mountain rescue; and the Royal Navy for rescue at sea.

The United Kingdom, with its surrounding seas, is divided into three areas of responsibility. Search and rescue operations in these areas are directed from rescue co-ordination centre (R.C.C.) at Roysth (No. 18 Group) Plymouth (No. 19 Group), and Aldergrove (Northern Ireland).

Provision of Search Aircraft

Coastal, Bomber, Transport and Flying Training Commands are responsible for providing, at short notice, search aircraft equipped, where possible, with droppable survival equipment. Coastal Command is additionally responsible for providing, at short notice, maritime reconnaissance land planes carrying airborne lifeboats. Fighter Command is responsible for providing aircraft search within an inland belt approximately 90 miles wide around the eastern and southern coasts of Scotland and England from Aberdeen to Portland Bill, and off the coast between the same points to a distance of 40 miles out to sea. Search and rescue aircraft are also available at short notice at certain naval air stations.

Dispatch of Search Aircraft

Search aircraft are normally dispatched by the R.C.C. concerned. However, where an individual station learns of a local incident, and can save time by dispatching its own search aircraft, it may do so, but must immediately inform the R.C.C. of the action taken. Thereafter all search and rescue activities must be controlled by the R.C.C.

Rescue by Surface Craft

A small number of naval vessels are available primarily for search and rescue duties and these are dispatched and controlled by R.C.C.s.

Other naval vessels (e.g. air training target vessels, emergency [illegible] at main naval base) not specifically allotted for search and rescue operations may be available. The control of these vessels remains with the appropriate naval commander, but he maintains close liaison with the R.C.C.

R.A.F. marine craft, and safety craft attached to naval air stations may be used to assist in rescue operations within the limits of their range and sea-going qualities. R.C.Cs. can seek the assistance of these craft through the appropriate station commander.

Lifeboats of the Royal National Lifeboat Institution may be asked to assist in rescue operations within 60 miles of the coast. Their speed however, is slow.

A merchant ship may be able to assist if the position of a "ditched" aircraft or survivor is precisely known. Otherwise merchant shipping can do little more than keep an especially sharp lookout.

Certain naval air stations possess amphibious aircraft capable of short-range rescue work. The R.C.C. may ask the station commander for assistance of one of these aircraft.

Alerting of the Search and Search Organisation by the Fighter Control Sytems

When a fighter controller learns a pilot under his control is "ditching" or abandoning his aircraft over the sea, he must:-

(a) Determine the position of the aircraft with the greatest possible accuracy. If necessary using the V.H.F. fixer service to supplement his radar.
(b) Immediately on receipt of the distress message, acquaint his chief controller of the occurrence and thereafter keep him fully informed.
(c) Pass the pilot any useful information, for example, his position in relation to the coast.
(d) Give every possible assistance to the pilot of any other fighter which may be operating over the pilot in the sea. Day fighters do not normally operate in smaller units than a pair and it is the duty of the accompanying pilot to circle the distressed pilot for as long as he can.

A chief G.C.I. controller, on being informed by an interception controller of a pilot's descent into the sea, would forthwith notify the control executive at the parent S.O.C. The control executive in turn would inform the sector controller and the air executive, and the air executive would notify the appropriate R.C.C. If it is daylight, the sector controller would almost certainly decide to send off a section of fighters either to relieve the fighter orbiting the distressed pilot's position, or to search for the distressed pilot, as the case may be. The closest liaison would be maintained between R.C.C., S.O.C., and the radar station(s) controlling the Fighter Command search and rescue aircraft.

Emergency V.H.F. Call by Aircraft

A continuous listening watch is maintained by selected aerodromes and all air traffic control centre on the following V.H.F. R/T channels:-

(a) The International Aeronautical Emergency channel - 121.5 m/cs.
(b) The Emergency and Flight Information Service channel - 116.46 m/cs.

The aerodromes also give D/F on these channels.

Bearings are passed from aerodromes to air traffic control centres over direct telephone lines. The air traffic control centres plot the bearings and co-ordinate, decide, and direct, the emergency action which is to be taken at the centre and at the aerodromes.

Safety

Aircraft not in immediate danger but in difficult conditions which may lead to an emergency, transmit a safety message preceded by the word "Security" repeated three times.

Urgency

Aircraft in danger and in very urgent need of assistance, which may possibly overcome the danger, transmit the message preceeded by the word "Pan" repeated three times.

Distress

Aircraft threatened by serious and immediate danger, and in need of immediate assistance switch on "Distress" I.F.F. and transmit a distress message preceded by the word "Mayday" and the aircraft call-sign repeated three times.

These calls may be transmitted on the frequency in use or on one of the distress channels mentioned above. The calls may be answered by any station but once two way contact has been established between the aircraft in the emergency and a station, that station assumes control of the aircraft until otherwise directed by the A.T.C.C.

RADIO WARFARE.

Radio warfare is the term used to describe the use of electronic or radio devices by opposing forces in time of war to disrupt, confuse and if possible, to overcome each others radar defences and radio communications, thus paving the way for successful air attacks. During the late war the opposing forces made use of radio warfare to a great extent, leading to many "successes" on either side. The experience gained emphasized the need to maintain an organisation in peace time charged with the task of developing radio warefare techniques and apparatus.

Every operational command in the R.A.F. has its special interest in radio warfare. This precis, however, deals only with Defensive Radio Warfare (D.R.W.) in particular with D.R.W. in Fighter Command, where it has reached its highest development.

Since radio warfare includes a defence, the term "Radio Countermeasures" (R.C.M.) is used to describe the action taken and devices used by the defending forces to nullify or minimise the radio attacks of the enemy.

Enemy Jamming.

There are three major ways in which the Radar defences of a country may be affected:-

(a) By jamming of Radar equipment

(b) By jamming of R/T communications

(d) By use of "window" (False information)

Jamming of Radar equipment.

Any radar station may be jammed, and the jamming may be intense enough to prevent detection of aircraft in the normal way. The effectiveness of the jamming depends on:-

(a) The frequency of the radar. (The lower the frequency of the and the wider the beam, the easier to jam. Thus Type 7 is easier to jam than Type 14.)

(b) The width of the main radar beam.

(c) The size, number and extent of the side lobes.

(d) The distribution and beam width of the jamming signal, i.e. whether it is distributed round in azimuth or in one spot bearing.

(e) The degree to which the radar performance is achieved by receiver sensitivity as compared with transmitter power, because any increase in the radar transmitter requires an increase in jamming power to the same ratio to produce the same effect, but an increase in the radar receiver sensitivity does not.

Use of "Window."

"Window" is the code name given to the use of thin strips of metal-coated paper which are either cut to the length of the wavelength in use at the radar station it is desired to affect, or in lengths of 400 ft. (code name "Rpoe") which will be effective against all frequencies. If such strips be dropped within the coverage of a radar station, responses will be displayed which are almost identical with radar echoes except in rate of horizontal movement.

The strips are thin and light so that they fall slowly (400 ft. per minute) through the air. In view of the slow descent responses will be observed for many minutes. "Window" is used to:-

(a) Disguise the size and form of a raid.
(b) To hide the subsequent approach of another raid through the "sown" area.

(c) To trick the defence into committing large formations of fighters to the interception of the supposed "area" raid, whilst the true raid is pressed home elsewhere.

Jamming of R/T Communications.

Any interference with the link between the controller and pilot of the fighter under guidance reduces the efficiency of an interception. Jamming in varying intensities and variations may sever the link, thus rendering fighter control in-effectual.

FIGHTER COMMAND D.R.W. ORGANISATION.

The aim of the D.R.W. Organisation in Fighter Command is three-fold:-

(a) To destroy enemy jamming transmitters, whether airborne or on the ground.

(b) To co-ordinate all information regarding the jamming experienced by the defence, so that partially, or unjammed facilities may be utilised to the best advantage.

(c) To deflect the attack of the enemy by use of:-
(i) special radio deception units
(ii) decoy fire units ("Starfish")
(iii) decoy lighting units ("Q" sites.)

LAYOUT OF D.R.W. Organisation.

Each sector within the C. & R. system is provided with a complete D.R.W. organisation of its own. Fig. 1 shows a simple layout of the equipment used.

FLOW OF D.R.W. INFORMATION.

Provision against Radar Jammers.

(a) All stations report interference in the form of:
(1) Station (Name) jammed
(2) Type of equipment jammed
(3) Grade of jamming
(4) Direction of jamming
(5) Any subsequent change in intensity and direction of jamming

to the C.F.P. tables.

(b) All stations excepting C.H. and C.H.E.L. have a special D.R.W. console provided, where an accurate bearing and time check of the interference is passed to the D.R.W. section at the C.F.P. which contains a triangulation table where the bearings from a number of stations are triangulated to give a Georef position which is passed to the Filter Table and then to the G.S.M's.

(c) At certain selected stations Ground centimetric D/F units are situated which obtain a bearing on the jammer. These bearings are transmitted to the C.F.P. D.R.W. section where triangulation takes place. A Georef position is passed to the C.F.P. and then to the G.S.M.'s.

(d) R/T. Jammer.

A number of V.H.F. D/F units are selected from the normal Sector V.H.F. D/F Fixer System to listen out on the Jammer's Frequency. Bearings are passed to the Sector Fixer Section at the S.O.C. A Georef is gained from the triangulation table which is passed to the C.F.P. and then to the G.S.M's.

(e) Jamming by R/T channels is passed from the Moniter Room at the S.O.C. to the C.F.P. (responsibility of the Supervisor in Track Telling)

(f) Fighters are controlled to attack the jammer.

(g) Jammer is destroyed (we hope!) by fighters using special apparatus to "Home" on it.

It will be seen that once the position of the enemy jammer is laid on the filter table, the reporting and control organisation is normal, with the exception of the special jamming "homing" fighters. For present purposes the D.R.W. organisation is best considered as it affects
(a) A.D.O.C.
(b) S.O.C.
(c) C.F.P.C.
(d) Radar stations.

A.D.O.C.

At the A.D.O.C. specialist D.R.W. officers are established, of whom the most senior of each watch is known as the "Command D.R.W. Controller." The Command D.R.W. Controller will supervise the conduct of D.R.W. generally throughout the Command, and will help the Air Defense Controller in appreciating the air situation in the light of Radia Warfare activity.

In wartime the Command D.R.W. Controller would have the power to stop any public radio broadcasting that might be useful to an enemy as a navigational aid.

A special D.R.W. Ops. Room is included a part of the A.D.O.C. and contains a situations map on which D.R.W. information from the whole country is plotted.

S.O.C.

A specialist signals officer is established at each S.O.C. known as the Sector D.R.W. officer, and included among his small staff is a special D.R.W. intelligence section.

The duties of the Sector D.R.W. officer may be summarised as:

(a) Helping the Sector Controller to appreciate the air situation in the light of radio warfare activity.

(b) Controlling the ground D.R.W. weapons of the Sector.

(c) Advising the sector controller on the best use of those fighters fitted with equipment enabling their crews to home on radio or radar jamming transmitted from enemy aircraft.

Each sector is equipped with the following D.R.W. apparatus:-

(a) H.F. and V.H.F. radio monitors for obtaining intelligence about enemy aircraft activity.

(b) H.F. and V.H.F. Jamming stations.

(c) A V.H.F. fixer system for locating enemy airborne radio jammers. This in in fact part of the normal V.H.F. R/T Fixer system which is big enough to allow a number of D/F. stations to be used solely for D.R.W. The particular D/F stations chosen for D.R.W. can be varied at a moments notice on authority of the Sector Controller. A special D.R.W. triangulation table is used.

(d) Stations for fixing the origin of transmissions from radar navigational aids fitted in the enemy aircraft. These are known as [illegible]tric D/F stations.

(e) High powered V.H.F. radia transmitters for use in fighter control during enemy jamming.

(f) Although not yet in force, each sector will, eventually, possess:-

(i) Special radio deception units.
(ii) Decoy fire units. ("Starfish")
(iii) Decoy lighting units. ("Q-sites.")

C.F.P.C.

The D.R.W. section in each C.F.P.C. receives information from the following sources:-

(a) Information about enemy radar-jamming and "window" dropping from the radar reporting stations of the Sector.

(b) General information about enemy radio-jamming (R/F) from the G.C.I. stations in the Sector.

(c) Fixex on enemy radio jamming form the triangulation centre of the V.H.F. R/T system of the Sector.

(d) Fixes on the transmission of radar (H2S) navigational aids in

enemy aircraft from a group of special centimetric D/F units, which are usually mobile.

A special D.R.W. triangulation table is installed for fixing the sources of radar jamming, which is then passed to the Filter Table for display and telling. In addition, the Filter Table will display:-

(i) The stations currently jammed.

(ii) The intensity of the jamming

(iii) The estimated position of enemy jammers

(iv) Areas sown with "Window"

<u>RADAR STATIONS.</u>

In the presence of jamming the radar station must attempt to:-

(a) Pass maximum information to the D.R.W. Section regarding the actual jamming itself.

(b) Introduce anti-jamming devices and procedures to ensure that the maximum amount of track information is passed to the C.F.P.C.

Defensive Radio Warfare

Defensive Radio Warfare Organisation

(1) Radio Countermeasures 9(R.C.M.). The most common and most important type of radio countermeasure is known as 'Jamming' Two kinds of jamming concern us - radar jamming and V.H.F. jamming.

(2) Radar Jamming. A radar on a Given frequency may be jammed by:-
- (a) Transmissions from an external source on or near that frequency
- (b) Dropping, from aircraft, strips of metallized paper ("window") cut to the wavelength of the radar concerned.

(3) V.H.F. Jamming. A V.H.F. frequency may be jammed by transmission from an external source on that frequency.

(4) While jammers may be installed on the ground or in aircraftm by far the most likely type would be airborne.

(5) Reporting the loss of facilities Enemy jamming has the effect of denying to us, to a greater or lesser degree, our V.H.F. radio and radar facilities. The first step in counteracting these effects is to ensure that the user is informed of such loss so that he may :-
- (a) Bring alternative facilities into use, where they are available, or
- (b) Be forewarned not to expect full efficiency from warning and control facilities.

The methods of reporting jamming will be dealt with in a later precis.

Tracking Jamming Aircraft.

(6) Tracking Radar Jammers The next stop towards counteracting enemy jamming is to track the jamming aircraft. The mean directioh of the jamming, can usually be determined from a radar effected. The range of the jammer cannot however be determined from radar. It follows that one radar alone cannot give the position of a jammer. This position can, however, be fixed by triangulation of the bearings of more than one radar of the same type.

(7) A special organisation has been set up at C.F.P.'s to obtain fixes on jammers in this way. Activities are centred around a triangulation table known as the D.R.W. table showing :-
- (a) The sector area and its approaches
- (b) The Georef graticule
- (c) All radar stations within the seotor
- (d) A compass rose orientated on each radar station.

(8) Fixes are obtained by demanding simultaneous bearings from more than one radar station of the same type, laying off these bearings and obtaining the fix in the normal manner. The fixes produced are told to the appropriate filter table.

(9) Tracking V.H.F. Jammers. Fundamentally, the problem of tracking V.H.F. jammers is the same as the problem of tracking radar jammers. In this case, however, within the control system, a fixing organisation already exists in each sector. Some of the V.H.F. D/F stations within such an organisation are released from their normal role, are set up on the frequency jammed and are required to pass bearings on the jammer for triangulation at the S.O.C. V.H.F. jamming fixes so obtained are passed by C.H.B. supervisors to the C.F.P. and displayed on the appropriate filter table.

(10) Enemy Transmissions other than Jamming In addition to transmissions made in order to harass the defenders, the attacking enemy makes transmissions for other purposes notably for navigations and bombing. An example of such an equipment i in H.2.S.

(11) In order to track the enemy bomber by means of transmissions made for the purposes of bomding, navigation etc., it is necessary to employ special equipment, capable of finding the direction of such transmissions. Such equipment is known as Ground Centrimetric D/F (Code word "Flange") It is sited at selected radar stations and its operators are required to pass simultaneous bearings to the D.R.W. table at the C.F.P., whence after triangulation, fixes are passed to the appropriate filter table. Such fixes, together with fixes on jammers may be regarded as D.R.W. fixes.

(12) Use Made of D.R.W. Fixes.
D.R.W. fixes received at the filter table are dealt with in two ways :-
(a) Where the D.R.W. fix can be related to an existing track, the D.R.W. information (radar V.H.F. or H 2 S.) is shown with the track, as ancillary information.
(b) Where the D.R.W. fix cannot be related to an existing track, a new track is produced and a hostile identification is alloted to it.

DEFENSIVE RADIO WARFARE

Duties of D.R.W. Crews

P.P.I. Observer

1. Passes the mean main bearing of R.C.M. Jamming as the nearest of eight cardinal points of the compass in the following manner:-

	STATION		TYPE		JAMMED		GRADE		DIRECTION
e.g.	Bawdsey	-	C.E.W.	-	Jammed	-	Grade 1	-	North East

2. All changes in direction and grading are to be passed over the plotting line:-

e.g. Change - Bawdsey - C.E.W. - Jammed - Grade 2 - East

3. When the P.P.I. is clear of jamming, this is repeated over the plotting line:-

e.g. Bawdsey - C.E.W. Clear of Jamming

4. Tells window by type i.e. Centrimetric as "Red Window" and metric window as "Green Window". When an aircraft commences to drop window this fact is reported as a suffix to each plot until dropping ceases. e.g. NORTH CG1020 - 1 - Red Window. The direction of drift is passed as soon as this can be assessed, "Red Window" - CG - drifting West.

5. Areas of window which have been dropped are passed by up to four GEOREF points defining the area obscured, the order in which these points are told being clockwise from the first. After the first definition of area of "dropped window", further definition is told only:-

(a) When there is a substantial change in the shape or size of the obscured area, or:-
(b) Upon request by the Filter Officer
(c) Examples:- (1) Red Window - stream - point one - CG1020 - point two - CG4020
(2) Red Window - area - point one - CG1020 - point two - CG1040 - point three - CG4050 - point four - CG5000

6. When window clears this is reported as follows:-

Red (or Green Window clear in Charlie George).

7. Track Telling Supervisors are responsible for the arrangements for telling V.H.F. jamming to the C.F.P.

8. G.C.I. V.H.F. Monitor The V.H.F. Monitor Supervisor at G.C.I's. tells immediately to the S.O.C. D.R.W. Tote the commencement and change of jamming on his particular frequencies. He indicates the grade of jamming and additionally reports each channel as it becomes clear.

9. Sector Operations Centre D.R.W. Tote Operator receives reports on V.H.F. jamming by order of frequencies from G.C.I. Monitor Supervisors and displays the frequency and grade of jamming upon that portion of the Tote reserved for his particular G.C.I.

Duties of C.F.P. Personnel.

10. C.F.P. Plotter

(a) Upon receipt of information that the station to which he is coupled is jammed, he calls for the appropriate D.R.W. plaque from the [illegible] Orderly, e.g. Bawdsey D.R.W. Green 1, according to the radar type [illegible] jamming grade.

(b) Places the D.R.W. plaque on the C.F.P. table with the centre of the base on the station pinpoint and the tip of the plaque pointing in the direction from which the jamming is reported.

(c) Leaves the D.R.W. plaque in position until the grading and direction changes or until the station reports "Jamming Clear".

(d) When "Window" is reported he indicates this to the Filter Supervisor first verbally and places window plotting counters on the table only when requested to do so by the Filter Supervisor.

11. Filter Controller exercises overall control of the relative emphasis placed on current radar and D.R.W. plotting having regard to the jamming state at any time. He directs the Filter Officer and the D.R.W. Supervisor as necessary in the use of radar equipments either for direct reading or for D.R.W. fixing. The use of anti-jamming devices at the various equipments, apart from independent C.H.E.L. stations, is dependent upon the Filter Controller's directive.

D.R.W. Triangulation

12. C.H.E.L. and C.H. stations do not pass bearings to the D.R.W. table.

13. Other reporting units are provided with a special D.R.W. circuit which appears at least at one P.P.I. for each equipment type. This circuit terminates at the C.F.P. D.R.W. table.

14. Ground Centrimetric D/F units tell direct to the D.R.W. Triangulation Table at the C.F.P. and the D.R.W. Supervisor at each C.F.P. is responsible for ground centremetric D/F fixing.

15. D.R.W. Supervisor

(a) The D.R.W. Supervisor ensures the resources available for producing an air situation by D.R.W. methods are used in accordance with the Directive of the Filter Controller. There is close co-operation between the Filter Officer and the D.R.W. Supervisor.

(b) He orders specific equipment to pass bearings at specific times and he "fixes" jammers from triangulation of such radar or Ground Centrimetric D/F Bearings.

(c) He ensures that all members of the crew are conversant with their duties and working efficiently.

(d) He is responsible for obtaining THM checks at intervals of thirty minutes.

(e) He ensures that Tellers pass all information from the Triangulation Table to the appropriate Filter Table.

16. Radar Bearing Setters

(a) Obtains bearings as directed by the supervisor, from the unit to which they are linked.

(b) Ensures that the bearings obtained are in fact from the type of equipment and at the time requested by the D.R.W. Supervisor.

(c) Lays off these bearings with marked cords or any other approved system.

17. Ground Centrimetric D/F Bearing Setters lay off, in yellow chinagraph, the bearings passed by the Ground Centrimetric D/F Operator and note in chinagraph on the line of bearings the type of equipment which is available, together with the time.

18. D.R.W. Teller - The D.R.W. teller is positioned to have an uninterrupted view of the D.R.W. Triangulation Table. He:-

(a) Passes all information on tracks which appear in the area of the D.R.W. table, for which he is responsible, to the appropriate Filter Table, e.g.

(b) (1) Radar Jamming Fix BG3456 repeat BG 3456
(11) "Sugar" Fix DK4321 repeat DK4321
(111) "Voice" Fix AB1234 repeat AB1234

(c) He passes all fades as indicated by the D.R.W. supervisor in the following jargon:-

Radar Fix BG3456 faded

19. D.R.W. Recorder

(a) The D.R.W. recorder is positioned in such a way that he has an unrestricted view of the D.R.W. Table.

(b) He records broadcast D.R.W. information as follows:-

(1) Time
(11) Fix
(111) Type of Fix - radar, V.H.F. or Ground Centrimetric D/F
(1V) "Sugar" fix is used to denote Ground Centrimetric D/F fix

20. The Filter Supervisor

(a) Relates V.H.F., Ground Centrimetric D/F or radar jamming fixes with a normal radar track where possible.

(b) Where a D.R.W. fix of any kind indicates a new track, he allots it a serial number tagged with the appropriate D.R.W. indicator.

(c) When a D.R.W. fix can be related to an existing track, the Filterer adds the appropriate D.R.W. indicator to the track.

(d) Allots automatically a hostile identification to any track produced solely by D.R.W. means.

(e) Removes from the table after one cycle of the colour change unit, such radar, V.H.F., or "Sugar" fixes that have been unrelated to any radar track and which have themselves not been continued forward in track form.

(f) Interprets "Window" reports from radar stations by use of the "Window" plaques which provide for:-

(1) flexible length and breadth display by addition of magnetic figures to the plaque and
(11) Drift. He uses a red plaque for centrimetric "Window", and a green plaque for metric "Window".

The type of "Window" is indicated by the counter colour used by the plotter.

21. Broadcast of D.R.W. Information from Filter Tables - When D.R.W. fixes of radar, V.H.F. or Ground Centrimetric D/F information have reached the filter table, they are broadcast in the same manner as other raid reporting information, and where so indicated, as ancillary information on an existing radar track. The following procedure is used:-

(a) Station V.H.F. and Radar Jamming and Grade Plaques are NOT told.

(b) The tellers tells all filter tracks in the normal manner and indicates jamming source, as follows:-

(1) New Track - H501, North West, CG1234, CG1234
1 no height, V.H.F. or "Sugar" or radar.

(11) H501 "Sugar" faded.

(111) The "Window" plaque is broadcast as follows and prefixed by the colour. e.g.

(a) "Red Window", Window - CG12, CG12. Area 55 by 25" (The measurement is in miles; the East/West distance is stated first)

(b) "Red Window, Window, CG12, drifting West (to 8th point of compass). The window areas continue to be displayed on the drift side of the window plaque.

(c) Upon removal of the window plaque by the Filterer the Teller broadcasts "Red Window" clear CG12.

Accept. 18

ANTI-AIRCRAFT ARTILLARY DEFENCE

ORGANISATION

1. Anti-aircraft artillary defences are of two kinds - heavy A.A. and light A.A. the function of which are

(a) Destroy enemy aircraft
(b) Prevent accurate attack

2. Heavy A.A. Artillery

Heavy A.A. guns are capable of engaging enemy aircraft flying at heights between 2000 ft. and the operational ceiling of the gun. Each H.A.A. regiment mans a number of gun positions up to a maximum of 6 each of 4 guns.

Heavy A.A. guns are deployed to defend areas which are most likely to attack. These are known as Gun Fire Areas (G.F.As.)

3. Control orders for H.A.A. guns are originated by Sector Controller advised by this A.A. Controller, implemented by the H.A.A. Executive and passed to Anti-Aircraft Operations Room (A.A.O.R.). The Air Executive is responsible for briefing aircrew of control orders and the Control Executive for briefing the G.C.I. Stations and Sector Fighter Marshals.

4. Army tellers at the C.F.P. pass relevant E.W. information of the air picture to the A.A.O.R. where it is displayed on a G.S.M. A.A.O.R. tellers relay relevant portions of the air picture to gun positions.

An A.A.O.R. directs the activities of the many gun positions forming a F.G.A. In large G.F.A's. there may be more than one A.A.O.R. In many sectors there are several G.F.A's. and therefore several A.A.O.R's.

5. The following control orders are used:-

(1) Normal Control Orders

red (a) Guns Free - Used to indicate that guns may be fired at all aircraft not recognised as friendly.

green (b) Guns Tight - Used to indicate that guns may NOT be fired at any aircraft unless the aircraft is recognised as hostile and fire will not endanger friendly aircraft.

(11) Directional Control Orders

The cardinal or half cardinal points are used to indicate the direction in which friendly fighters are flying across the G.D.A. When a directional control order is in force NO target which is flying on a heading 45 degrees either side of the direction specified is to be engaged. But hostile or doubtful aircraft flying in any other heading may be engaged.

On cancellation of a directional control order the guns revert to the previous gun state.

(111) Emergency Control Order

On certain occasions such as a friendly aircraft in an unexpected emergency, the sector controller may make use of the emergency order "Hold Fire". When this order is given, guns may not fire under any circumstances, regardless of enemy action.

On the order "Cancel Hold Fire" guns revert to gun state in force prior to the imposition of "Hold Fire".

6. The gun fire areas of the larger A.A. Defended Areas are divided into a number of specially planned control areas. These areas are numbered, and control orders are given in the form "GUNS TIGHT" followed by the name of the sector, followed by a specified area or areas with a height e.g. "GUNS TIGHT SOUTHERN NINE BELOW ONE FIVE."

71 Height Restrictions

Normal control orders are invariably qualified by a height.

(a) Single Height used when it is desired to restrict the gun fire above or below a given height. Height is given in thousands of feet prefixed by "above" or "Below" e.g. "GUNS TIGHT ABOVE TWO ZERO"

(b) Height Sandwich used when it is desired to enclose friendly aircraft in a height sandwich, two heights in thousands of feet are ordered, the lower being given first e.g. "GUNS TIGHT CALEDONIAN SIX BETWEEN TWO ZERO AND TWO EIGHT" 20 - 28.

In both cases a minimum safety height of 3000 ft. is to be allowed for by the sector controller.

The lowest height of engagement for H.A.A. guns is 2000 ft. and control orders take effect above this height. In special cases where H.A.A. engagement may be required below 2000 ft. the upper height is prefaced by the minimum height required.

8. Not more than two normal and one directional control order may be in force at the same time in any control area. The emergency order "Hold Fire", however, may be superimposed over any existing control order.

9. The commanding officer of a naval vessel has the right to open fire on any aircraft by which his ship is being directly menaced, regardless of any Gun Control Orders or restrictions in force at the time.

APPLICATION OF CONTROL ORDERS TO THE ENGAGEMENT BY H.A.A. FIRE OF VARIOUS TARGETS

This table shows whether engagement by H.A.A. is permitted or not.

Type of Target	Guns Free	Guns Tight: If Friendly aircraft are not thereby endangered	Guns Tight: If friendly aircraft are thereby endangered
Recognised Hostile	Yes	Yes	No
Hostile Recognised by Hostile act	Yes	Yes	No
Mixup'	Yes	No	No
X-Raid	Yes	No	No
Serial	Yes	No	No

NOTE 1 - Hostile Act An aircraft commits a hostile act if:-

(a) It attacks
(b) It dives directly at an objective
(c) It makes a direct low level approach at an objective
(d) Drops parachutists or flares in specified areas without the defences being notified
(e) The radar response from the aircraft indicates that it is engaged in R.C.M.

<u>NOTE 11</u> - <u>Aircraft Tracks with Serial Numbers Only Shown</u>

When the gun state ordered by S.O.C. is "GUNS FREE" all such aircraft tracks are to be treated as "Hostile" by H.A.A. gun positions unless otherwise ordered by Sector Controllers, or until such time as they are identified as "Friendly".

TOTES AT S. O. C.

SQUADRON STATES BOARD

The Squadron Sates Board is divided vertically into four sections. Each sector contains the following information:-

SECTION 1	Released
	On call 30 minutes
SECTION 2	Base
	Squadron Number
	Callsign
	Aircraft Type
SECTION 3	10 Minutes available
	Ordered to Readiness
	5 Minutes Readiness
	Ordered to Standby
SECTION 4	2 Minutes Standby
	Ordered Off
	Total Number Airborne
	Total Number on Turn Round

Individual formation colours are not to be used on the Squadron States Board.

"Appendix" aircraft are to be shown by the following means:-

Appendix Upper Band:-	Black figures on half-green half-white back ground, (upper half green).
Appendix Lower Band:-	Black figures on half green half-white back ground, (lower half green).
Green Salad.-	Black figures on an all green background.
ARIX 18006:-	Black figures on half-green half-French blue background, divided vertically.

The information may be passed to the tote either direct from Wing Operations Room, or via the Air Executive's assistant.

MISSION TOTE

This tote shows details of missions being flown by fighters of the sector.

The headings of the tote are as follows:-

(1) SERIAL NUMBER	Each mission is given a serial number for quick reference.
(2) CALLSIGN	Of each unit or formation.
(3) TIME AIRBORNE	
(4) MISSION	
(5) CONTROL	Usually an abbreviation of the G.C.I. station controlling the mission.
(6) CHANNEL	VHF channel being used to control the mission.
(7) REMARKS	

4B
Precis 7

TOTES AT A.D.O.C.

In order that the Command Controller can supervise the air situation, it is necessary to provide a comprehensive tote display in the A.D.O.C., giving an accurate and up to the minute picture of the Command's fighter resources, missions undertaken and airfield serviceability.

The data required is "told" by the Sector Tote Teller located in the S.O.C.

CRAFT

AIR~~FIELD~~ STATES

The Sector Tote Teller passes to the A.D.O.C. the current availability of the Sector aircraft under the following headings:-

(a) COMBAT AVAILABILITY (All Weather) (Day) — The number of serviceable aircraft with crews available for combat. (Given to separate all weather and Day totals).

(b) ON CALL 30 MINS. AVAILABLE 10 MINS. — Total number of aircraft which could be put into the air on Air Defence Controller's order within 30 mins. i.e. all aircraft at 30 and 10 minutes state. (Given by airfield and aircraft type).

(c) READINESS STANDBY — Total number of aircraft which could be put into the air on Air Defence Controller's orders within 5 minutes i.e. all aircraft at readiness and standby. (Given by airfield and aircraft type).

(d) TURN ROUND — Total number of aircraft in a state of "Turn Round" i.e. all aircraft landed on completion of a mission. The aircraft will remain under this heading until they are "Turned Round" and brought to a new state. (Given by airfield and aircraft type).

MISSION STATES

The Sector Tote Teller also passes details of Missions allocated to the aircraft of the sector. This information is told by aircraft totals followed by Mission e.g. EXETER, 12 Meteors, Hostile 206.

AIRFIELD STATES

These states are told by the Sector Tote Supervisor to the Air Defence Operation Centre Tote Supervisor in the following form:-

Bleach - No Information

Green - Fully Operational
Yellow - Emergency Operational
Red - Non Operational

e.g. Airfield Serviceability. Tangmere - Green.

The following is a sketch of the headings of the Squadron States and Mission States Totes.

Tote at ADOC.

S SECTOR	COMBAT AVAILABILITY A A.W.	D DAY	T TYPE	B BASE	TR TURN ROUND	AVAIL 10 CALL 30	RS READINESS STANDBY	ORDERED OFF	MISSION	ORDERED OFF	MISSION

TOTAL SUMMARIES

This tabulates the total number of fighters in each sector:-

(1) At each of the states shown on the Aircraft States Board.
(2) Scrambled against each Hostile raid,

CONTINENTAL LONG RANGE EARLY WARNING DISPLAY

The Continental Long Range Early Warning Display is a vertical perspex screen upon the rear of which is plotted (with annotated arrows) information received from reporting centres on the continent.

HISTORICAL PLOT

A vertical perspex chart the complete reported truck of any chosen raid may be recorded by plotting the consecutive positions of the riad from the G.S.M.

ENEMY AIRCRAFT APPRECIATION BOARD

(1) TYPE	(2) OPERATIONAL (In range of U.K)	(3) RESERVE	(4) COMMITTED	(5) BALANCE
LIGHT BOMBER				
MEDIUM BOMBER				
HEAVY BOMBER				
JET BOMBER				
FIGHTER.				
VARIOUS				

Columns (2) and (3) are maintained by an intelligence officer.. Column (4) and (5) by one of the Air Defence Controller's assistants from the information shown on the G.S.M.

WEATHER DISPLAY

The weather display consists of synoptic charts together with current weather forecasts.

5

IMPORTANT POINTS IN G.C.I. CLOSE CONTROL INTERCEPTIONS

1. When establishing contact with your fighter use full callsigns, (e.g. Tiger Red This is Bluebottle 17).

2. Once contact has been satisfactorily established, cut your own callsign and abreviate the fighters - only do this if you are the only people using the R/T Channel.

3. When starting an interception the following must be transmitted as soon as contact has been established:-

   (a) Vector and angels (Vector Two Six Zero Make Angels Thirty).
   (b) Range and direction of target (Target Forty Miles South East).
   (c) Targets height, estimated course and speed (Targets Height Forty Thousand Feet, Estimated Course Zero Nine Zero, Speed Point Nine).

4. As soon as possible pass a comparitive height, relative to the fighter. If the fighter is climbing, take the fighters height last and pass the comparitive as quickly as possible. (Target Now Twenty Thousand Feet Above You).

5. Inform the fighter of the type of interception you plan and which direction the target well cross him in the closing stages. (This is a parallel head on interception. Target will cross you starboard to port).

6. Once your target and fighter have closed to twenty-five miles, keep ranges and clock-codes giving (Target Now At Eleven O'clock Range Twenty-Three Miles).

7. If the fighter is going to have to do a hard turn to intercept successfully, warn him. Avoid this if you can and remember the greater the height the slower the turn (I Shall Be Turning You Hard to Port: Hard Port One Nina Zero Rate Four (if possible at fighter's height) Port One Nina Zero.

8. If the target changes course, speed or height pass the information as soon as the change is noticed, don't wait for an accurate assessment from the crew - you can pass that later (Target Now Turning North: Target Appears To Be Increasing Speed: Target is Diving).

9. When you turn the fighter in behind the target let him know (Port Zero Nina Zero, Targets Course, Target Now Twelve O'clock Range A Half).

10. Always pass pigeons immediately after "Tally-ho' or Judy and then shut-up until asked for more help, but don't go to sleep, keep an eye on the interception in case the fighter loses contact with the target (Your Pigeons Zero One Zero Range Ninety).

7

TRACK PRODUCTION AND THE NECESSITY AND METHODS OF CO-ORDINATING AND FILTERING INFORMATION

1. Reporting stations of the same type are positioned sufficiently close together to afford a large amount of overlapping horizontal cover as a safeguard against the unserviceability of one unit of the chain. Again reporting stations of different types are positioned close together to give overlapping coverage in the vertical plane.

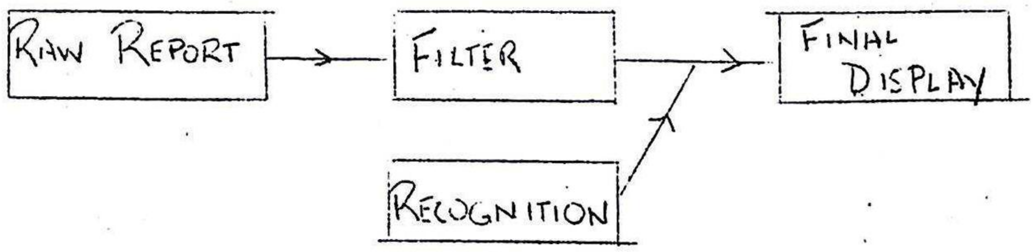
2. It is obvious therefore that an aircraft within range of the reporting system may be discernible, at any one time, by more than one station of a given type, and by more than one station. That is to say any single aircraft or information, will frequently give rise to two, three or even more, simultaneous but distinct reports from different radar stations.

3. Since these reports are all liable to be inaccurate, in varying degrees, in plan position, height and strength, they will have the appearance of relating to a number of separate raids. The confusion which would result if the radar stations reported direct onto user's G.S.M. can be readily conceived. Therefore between reporting source and final display a stage of refinement and integration known as "Filtering" is interposed.

4. By filtering reports during their flow from source to user we can hope to secure a co-herent ultimate picutre which will represent actual activity with the greatest possible accuracy. But to render this final representation fully communicative to the user it is still necessary to subject the flow of reports to a further process known as "Recognition".

This involves distinguishing hostile tracks from friendly tracks. The process does not delay the final display of filtered picture, however, as dacisions concerning identity are incorporated in the filtered picture at the filter table, as and when made.

5. Here then is the sequence in which reports must be treated during passage from source to user.



FILTERING TECHNIQUES

Plan Position Filtering

The prime requirement demanded of the filter supervisor is to represent every enemy threat with the utmost speed and enough accuracy not to confuse the Raid Recognition Officer or the Control organisation. At long ranges in particular, accuracy should be sacrificed to speed as early warning and an indication of range are more essential than a correct plan position. At shorter ranges more precision is desireable as controllers are forced, once the track comes within range of their radars, with the task of correlating their G.S.M'S. with their radar displays.

The filter supervisor attempts to compensate for time losses between reporting source and final display by filtering ahead of the reported position by some appropriate variable distance.

Treatment of C.H. Reports

Plan positions from C.H. stations are accurate in range but generally inaccurate in bearing. The filter supervisor must therefore

interpret a C.H. position as an indication of a circular constant range arc centred upon the C.H. which is the focus of the aircraft's true position. Filter tables are marked with a series of circular "range rings" (usually at intervals of 10 nautical miles) around the position of each C.H. station in order to facilitate such interpretation when two C.H.'s are both reporting the same raid its position can be accurately found, being the point of intersection of two areas (a technique known as "range cutting").

Treatment of other Reports

Plan positions reported from radar stations other than C.H.'s may be accepted by the filter supervisor without interpretation - unless he has reason to believe that the station is off-calibration, or that particular reports embody telling or plotting errors.

Filtering Direction of Flight

A Whilst tellers quote direction of flight only to the nearest cardinal or quadrantal point greater accuracy can be revealed by the G.S.M. On this display three arrows are displayed for each track so the user can by visualizing a line through the arrow heads, derive a more precise knowledge of a raid's direction.

Assessment of Direction

In filtering C.H. reports the filter supervisor is himself required to assess direction of flight. If more than one C.H. is reporting the filter supervisor can determine plan positions by range cutting, and the direction of flight will thereby be disclosed. Where only a single C.H. station's reports are available the filter supervisor usually assumes a mean line of advance between a number of successive plots (always accepting the C.H. ranges as correct).

Height Filtering

The filter supervisor is required to quote height only by one of the even values in thousands of feet. This, however, does not imply that his estimates are accurate to plus or minus 1000 ft. In general accuracy to plus or minus 5000 ft. is acceptable.

Type 7 and 13 height finding reports are as accurate as required in track production but C.H. heights are less dependable. The most common technique of height estimation on C.H. used by filter supervisors is "Pick-up Heights". Specially prepared "Pick-up Height Charts" which show estimated heights for each C.H. station for first detections at a series of ranges at 10 mile intervals, measured both along and at 450 degrees to the line of shoot. This chart assumes a first pick-up Z value of Z = Z.

Strength Estimation

The filter supervisor is required to filter raid strength by one or other of the values 1, 2, 3plus, 6 plus, 9plus, 12plus, 15plus, 25 plus, 50plus, and 100plus, but does not pretend to an unvarying accuracy within or even approaching these limits.

C.H. PICK-UP HEIGHT CHART

Station Name	RYE C.H.										
Range from Station	30	40	50	60	70	80	90	100	110	120	130
Pick up height along L.O.S. (Thousands of feet)	2	3	5	7	9	12	15	18	22	25	28
Pick up height 45° off L.O.S. (Thousands of feet)	2	3	5	8	9	12	16	21	25	27	30

C. H. E. L.

"RATS" ORGANISATION & REPORTING OF SHIPPING TO NAVAL OPERATIONS ROOM

1. Functions:- The functions of the C.H.E.L. stations within the Reporting Organisation are:-

(a) To provide warning of the approach of low-flying aircraft passing the information direct to the S.O.C.

(b) The reporting of low-flying aircraft and of medium flying aircraft to the Filter Centre.

(c) The reporting of surface vessel activity to the Naval Operations Room.

(d) The minor role of passing "Nubex" reports as required to the Meteoroligical Office.

2. Equipment

(a) RADAR:- Radars Type 54 or Type 14 mk 9 may be used for C.H.E.L. reporting.

(b) CONSOLES:- Normally Console 64 with Console 61A an an "A" scope is used.

3. "RATS" Reporting

The critical "top" height for the reporting of "Rats" by seaward reporting radars is 500 feet. The S.O.C. "Rats" P.P.I. mask carries a marker line which indicates the pick-up range at which the relevant aerial head will pick-up a small/medium target with an upper height limit of 500 feet. The position of this marker is decided by the Station Senior Supervisor in the light of his local knowledge of the radar cover. The "Rats" P.P.I. observer is concerned only with plotting aircraft upon which the first pick-up is at or within the marker. The plotting circuit is connected directly to the S.O.C. "Rats Table" and to a plotter at the continuity table.

Where a P.P.I. console is used both for reporting to the Filter Centre and also direct to S.O.C. "Rats" organisation, a 120 N.M. radius "Georef" mask is fitted, but where there are separate consoles for each of these functions the "Rats" console is fitted with an 80 N.M. radius mask whilst the other carries a 120 N.M. mask.

Reporting to the C.F.P.

Tracks are passed to the C.F.P. in the normal manner. Those tracks which fall with the "Rats" classification are told as "Rats" to the C.F.P. e.g. N.E. CG1234 1 at Rats H101.

Reporting to Naval Operations Room

The surface Vessel Reporting P.P.I. reader passes Georef positions on all surface vessels within an area designated by the Naval Operations Room. He is in intercommunication with the Continuity Plotter (Surface Vessel) and the Naval Plotter.

The Continuity Plotter allots an internal track number to each initial plot commencing at 21. He interjects, after each plot passed by the P.P.I. observer, the allotted track designation.

That is, the internal track number until the N.O.R. track designation has been received.

Full Naval identification and designation consists of a letter (the ident), figures (track number), and a suffix letter indication the N.O.R.

The strength of track is passed as two figures e.g. Zero Two vessels means two vessels.

The continuity plotter assesses the speed of each surface vessel and writes the speed against the track e.g. '8 knots' and interjects this information after the track designation.

Naval Identification

F - Friendly Vessel
X - Unknown Vessel
J - Enemy Vessel

"A" Scope

The "A" scope may be used to assess strengths of aircraft or surface vessels.

NUBEX Reports

Centrimetric radar equipment are easily affected by heavy cloud formation. Whilst this is undesirable from the reporting point of view, it is a boon to the weather experts for they can have exact information on cloud formations.

In order to facilitate the passage of this information a code system has been devised. The code is as follows:-

MET. NUBEX GGgg xxxx xxxx DDDAA hhdd

Where:- GGgg - Hours and mins. in Greenwich Time (z)

xxxx xxxx - Position to the nearest minute in "Georef" of the centre of the Radar response (i.e. Four letter and four figures).

DDD - Direction in degrees towards which cloud is moving.

AA - Area covered by cloud expressed in one-sixth degree squares (10 mins) of latitude and longitude.

hhh - Height of top of radar response in hundreds of feet.

dd - Orientation to nearest 10 degrees of major axis of cloud area when the top of the echo appears flat. When the top of the echo has one or more peaks superimposed on the average level, 50 will be added to dd and hhh will refer to the highest peak.

Example of a Nubex Report

MET NUBEX 1040 MKBG 4545 01012 05024

Nubex report 10.40 hours, cloud formation centred on BG4545 moving 010 degrees covering 12 grid squares, height of cloud top 5000 ft.

Major axis 240 degrees with 5000 ft. indicating highest peak.

~~Precis 19?~~ 17
~~Precis 19.~~

METHODS OF PLOTTING A RATS TRACK AT A FILTER CENTRE

1. All aircraft except those known to be friendly flying below 500 ft. oversea, and 5000 ft. overland are designated "Rats".

2. When the plotters at the filter centre receive a "Rats" plot from seaward reporting radar they display a height symbol of 1.E (one estimated) against the track. Plots from R.O.C. Tellers are told as normal tracks without "Rats" prefix and heights are passed as 1, 2, or 4.

3. The Filter Supervisor considers the height information of 1.E with any other at his disposal and he filters the height in the norman manner. When he considers the information correct, or when there is no other height information, he places a height symbol of 1 (one) on the appropriate raid plaque.

4. The Teller at the filter centre tell these tracks in the normal manner without special priority.

SIGHTING REPORTS

A sighting report when received by the Interception Controller is to be passed to the S.O.C., by two methods:-

(a) By telephone or inter-communication system

- (i) From Interception Controller to Chief Controller
- (ii) Chief Controller to Control Executive
- (iii) Control Executive to Tactical Intelligence Officer and Sector Controller

(b) By normal telling and display

- (i) From Interception Controller to P.P.I. Reader
- (ii) P.P.I. Reader to G.C.I. Fighter Table
- (iii) G.C.I. Fighter Table to Sector Fighter Table

DUTIES

Interception Controller

He is responsible for passing all sighting reports immediately to the Chief Controller and ensuring that the P.P.I. Reader tells the sighting report to the Fighter Table, using correct procedure.

Chief Controller

On receipt of a sighting report from the Interception Controller, the Chief Controller is to pass the information to the Control Executive at the S.O.C. and to ensure that the correct symbol is displayed on the G.C.I. Fighter Table.

Control Executive

He is to pass the report to the Sector Controller and Tactical Intelligence Officer and ensure that the correct identification symbol appears on the Sector Fighter Table.

P.P.I. Reader

When given a sighting report by the Interception Controller he is to pass it to the Fighter Table/Screen using the correct telling procedure as detailed below:-

G.C.I. and S.O.C. Fighter Plotters

On being passed a sighting report they are to remove the symbol "Target" prefix to the serial number and replace it with the correct identification symbol as detailed in Appendix "A".

G.C.I. Fighter Teller

He is to tell all Fighter and Target information as detailed in the C. & R. Instruction dealing with telling procedure.

TELLING AND DISPLAY PROCEDURES

The P.P.I. Reader is to tell the information ONCE

e.g. North West, Charlie Fox 3450, Hostile 123
Now I.L. 28, Height Two Zero.

He is then to revert to normal telling jorgan:-

e.g. North West, Charlie Fox 2554, Hostile 123,
Height Two Zero.

On receipt of a change of identification he is to pass the new information thus:-

North West, Charlie Fox 2055, Change -
Hostile 123 Now I.L. 28 Escorted,
Height Two Zero

The G.C.I. Fighter Table/Screen Teller is to tell to the Sector Operations Centre the identification on two successive plots using the same jorgan as does the P.P.I. Reader when telling to the Fighter Table.

METHOD OF DISPLAY

(a) G.C.I. Fighter Plots - Horizontal Display

When a horizontal table is used, display of "type" of aircraft is to be done by substituting symbols depicted in diagram for "Target" prefix to the serial number.

(b) G.C.I. Fighter Plots - Vertical Display

When a vertical screen is used, identification is to be written in chinagraph.

(c) S.O.C. Fighter Plots - Horizontal Display

As for G.C.I. Fighter Plots - Horizontal Display.

NOTE:- Sighting reports are to be passed from the S.O.C. to the A.D.O.C. via Intelligence Channels

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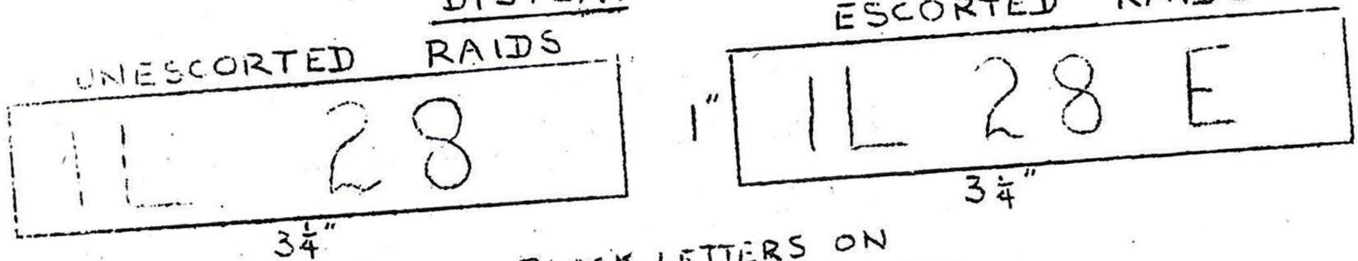
DISPLAY



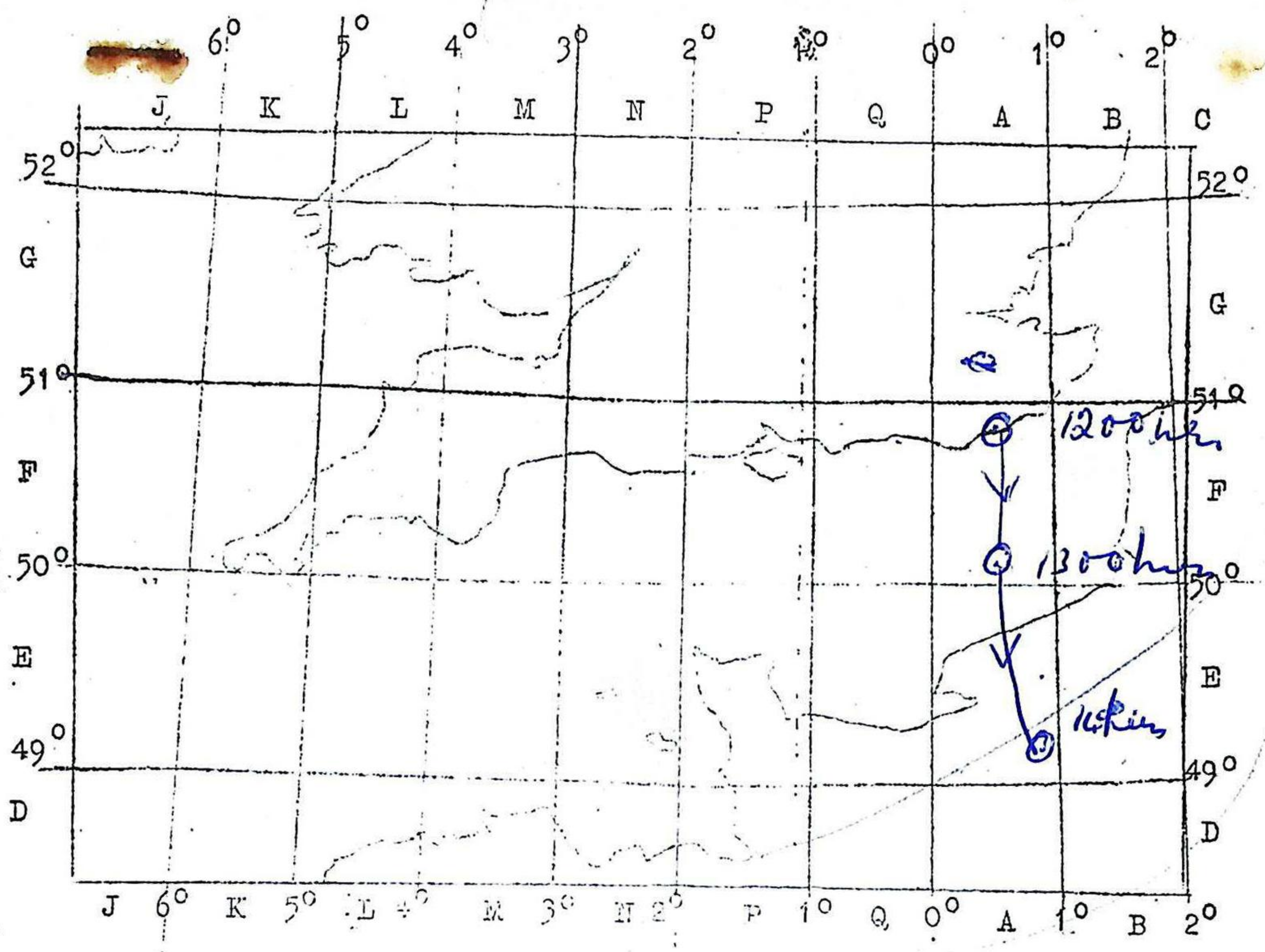
BLACK LETTERS ON
YELLOW BACKGROUND

NOTE :- GCI STATIONS TO MAKE THEIR OWN STRIPS.

TELLING PROCEDURE AT THE C.F.P.

FILTER DISPLAY	SIGNIFICATION	TELLING PROCEDURE
Halma, raid plaque with Serial Number 501, one aircraft, no height. Pos'n Halma CJ1234	Initial Plot, new raid no direction or height (Probably a C.H. Plot)	New Raid, Serial 501, no direction, Charlie Jig 1234, Charlie Jig 1234, One no height
Halma with white arrow pointing N.E. with arrow head in CJ1234, Serial 501, one aircraft, no height	Filter Supervisor established direction	Change, Serial 501 North East Charlie Jig 1234, Charlie Jig 1234, One no height
Coloured heart shaped arrow in pos'n CJ2749 pointing N.E., plaque showing Serial 501, with strength 1 and height of 16	Change in plan position and ancillary (1st height)	Change, Serial 5ol North East Charlie Jig 2749, Charlie Jig 2749 now one at one six
Coloured heart shaped arrow in position CJ3050 pointing N.E., plaque showing F501 strength 2 and height of 20	Change in plan position, change in identification, number of aircraft, and height	Change, Serial 501, now Fighter 501, North East Charlie Jig 3050, Charlie Jig 3050, two at two Zero
Filter Supervisor removes plaque (F501) from the table and draws tellers attention to it	Track to be removed from the table	Change, F501 now removed, F501 now removed
The Filter Supervisor moves plaque (F501) into A.R.H452, shown by 2 or 4 area filter corners. An A.R. plaque placed in the area shows identification, strength and height. A large filter arrow shows direction of movement. Plaque F501 is placed above the A.R. plaque and the Filter Supervisor draws the attention of the teller	F501 has entered A.R.H452 and plaque has been placed above the Mass Raid	Change, F501 now merged with Area Raid Hostile 452 (Repeated)
Four Filter Corners 1 - 4 Large Filter arrow on centre of leading edge of area indicating direction and area. Plaque showing identification, strength and height	Area Raid Reporting adopted	Area Raid, Hostile Four Zero One, Area One Zero by One Zero, West Baker George Four Zero Three Zero, Baker George Four Zero Three Zero, Nine Plus at Four Zero
Two Filter Arrow heads together at 90 degrees in CJ3646, plaque showing F511 one aircraft at 10,000 ft.	Fighter 511 orbitting position CJ3646 at 10,000 ft.	Change, F511 now orbitting in CJ34, CJ34

FILTER DISPLAY	SIGNIFICATION	TELLING PROCEDURE
Filter Supervisor draws tellers attention to Filter Arrow in CJ1030 and says "Reposition" and places a heart shaped arrow in CJ1058 with plaque showing F511, one aircraft at 20,000 ft.	New position dictated possibly by beam radar on Filter Controller's decision	Change, reposition F511 now CJ 1058, CJ1058



Sector Fighter Identification Teller

This teller acts as the links between the sector operations room fighter displays and the R.R.O. He is positioned overlooking the sector fighter table and fighter mission tote and is provided with a two way telephone circuit to the R.R.O. The teller wears a head and breast set at all times.

Details of fighter missions are passed to the R.R.O. as they appear on the tote, together with any information requested by the R.R.O. on the whereabouts of any specific fighters as plotted on the fighter table.

Means of Recognition

Apart from fore-knowledge of the movements of friendly aircraft made available by the R.R.S. and the Sector Fighter Identification Teller the R.R.O. has various other means to assist him in recognition. They are:-

(1) Track Behaviour
(2) I.F.F. reports from R.R.U.
(3) R.O.C. reports
(4) Radio fixes on friendly aircraft
(5) D.R.Y. reports concerning enemy air activities
(6) Sighting reports from friendly aircraft
(7) Reports of hostile acts

Recognition Categories

Raid recognition is determined in one of five categories:-

(1) H - Hostile
(2) X - Unidentified
(3) F - Friendly Fighter
(4) M - Mix-up - This label is used when hostile or unidentified tracks merge with and cannot be distinguished from fighter tracks.
(5) A - Allied - This identity is used for all tracks of friendly aircraft other than fighters.

NOTE 1 When fighter and allied tracks merge and cannot be separately distinguished, the letter "F" or "A" is allotted according to which type is in the majority.

NOTE 2 When unidentified tracks merge with friendly aircraft the letter "X" is allotted.

X, u.

9

DESCRIPTION AND USE OF PLOTTING EQUIPMENT IN THE CENTRALIZED FILTER PLOTTING CENTRE

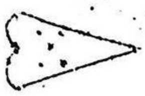
1. Non Directional

C.H.	Roman figures corresponding to the figure shown at time of use on the pulse indicator	IV
Type 80	----------------------------------	80
F.P.S.3	Lower or mixed beam	F
F.P.S.3	Upper beam where a separate channel is allotted	F
Type 7	----------------------------------	7
C.E.W.	Combination, Type 14 mk 8, and Type 14 mk 9 (8 + 9)	W
C.E.W.	Type 14 mk 8 where a separate channel is allotted (Plain)	8
C.E.W.	Type 14 mk 9 where a separate channel is allotted	9
C.H.E.L.	Elements (all radars) when reporting to C.F.P. and Type 54	(BARS)

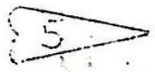
NOTE:- The background of each counter is of the sation colour. The back of the counter bears no figure, but is coloured and is used to indicate C.H.E.L. element non-directional plots when necessary.

2. Directional Plots

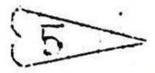
Type 80 — In station colour, dots in accordance with the current display of the pulse clock



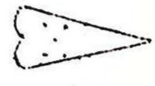
F.P.S.3 (UPPER Beam Plain) — In station colour, arabic numerals in accordance with the current display of the pulse clock



Type 7 — In station colour, arabic numerals in accordance with the current display of the pulse clock



C.E.W. Aerial Combination — In station colour, dots in accordance with the current display of the pulse clock



C.H.E.L. Elements (all radar) Type 54 or C.E.W. [illegible] — When reporting as a separate channel bars in accordance with the current display of the pulse clock

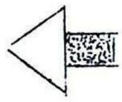
C.E.W. Type 14 mk 8 — When reporting as a separate channel, to be displayed in station colour

Directional Initial Plots — Both a non-directional counter indicating the radar type and a directional counter are displayed as below:-

Directional Type 7 initial plot display

3. R.O.C. Plots

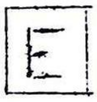
Filter arrows are used with the head coloured in accordance with the current display of the colour change indicator. The shaft of the arrow is black.



4. Height Counters

(a) No Height ----------------

(b) Estimated Height----------



(c) Height-------------------

(d) Plus Height---------------

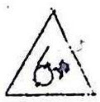
(e) Minus Height--------------

These counters are displayed in the station colour with each height received.

5. Strength Counters

(a)

(b)



Displayed initially and with every change received in the station colour.

6. I.F.F. Counters

(a) Mode 1 - I.F.F. mk 10

Identification rec. of operational friendly a/c without discrimination of friendly fighters

(b) Mode 2 - I.F.F. mk 10

Identification rec. of a Particular friendly fighter for [illegible]

(c) Mode 3 - I.F.F. mk 10

Identification & rec of friendly fighters definitely engaged upon air defence sorties

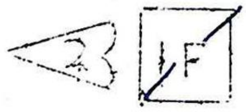
(d) Fighter - I.F.F. mk 111G

(e) Allied - I.F.F. mk 111A

(f) S.O.S.

(g) Unaccompanied mk 10 I.F. Plots

Directional



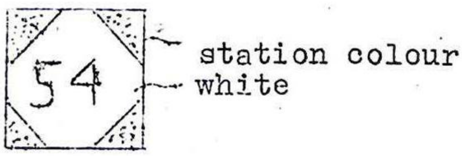
Directional plotting colour appropriated to radar channel. Background to the above plaque in station colour.

7. Track Numbers

Displayed in the station colour with every plot. The numeral represents, initially, the last digit of the station internal track number. When the track is serialized the numeral is changed to conform to the last digit of the serial number, and this change indicates that the serial has been passed to the station concerned.

8. Fade Plaques

These are basically white. The station plotting is shown thereon and conforms to paragraph 1, apart from C.H.E.L. elements, which are marked E.L. when the information is from equipment other than Type 54. Type 54 fade plaques are marked 54.



9. Controlled Fighters

Displayed in the station colour and applied to the tail of the raid plaque, by means of the magnetic base. Removed when the station concerned ceases control of the fighter tra ck concerned.

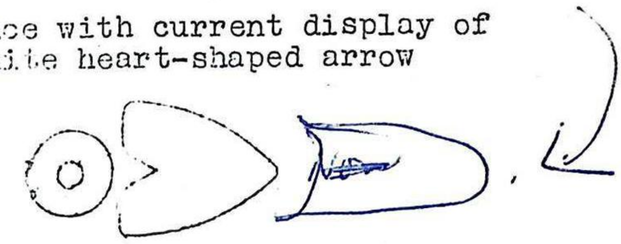
FILTER EQUIPMENT

1. Initial Filter Position (Non-Directional)

A Halma, coloured in accordance with the current display of the colour change clock

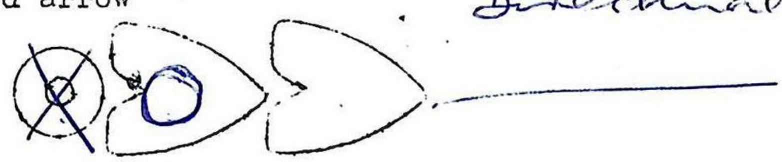
2. <u>Initial Directional Filtered Position</u> Non directional

A Halma coloured in accordance with current display of the colour change clock, and a white heart-shaped arrow indicating the direction.



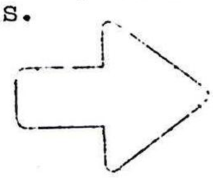
3. <u>~~Secord~~ Directional Filtered Position</u>

A white heart-shaped arrow Directional



4. <u>Subsequent Filtered Positions</u>

A tracking arrow of a colour not likely to be confused with tracking arrows of adjacent tra cks.

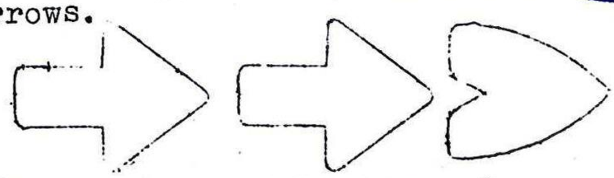


The same colour, once allotted, is maintained for all subsequent filtered positions (without ancillary change) unless a change is necessitated to avoid confusion, when all tracking arrows associated with the track in question are changed.

5. <u>Change of Ancillary Information</u>

A coloured heart, shaped arrow, the colour COTRASTING ~~corresponding~~ to the tracking arrows.

61 Repositioned



6. <u>Raid Plaques</u> (Track originated by Radar)

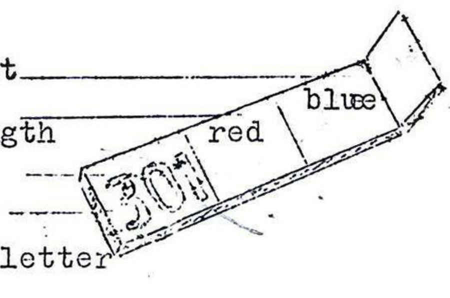
(a) Normal

space for height

space for strength

Serial number

space for identification letter



(b) <u>R.O.C. Plaques</u> - These have a two figure serial number and a suffix letter, indicating the originating R.O.C. centre. The suffix being applied by magnetic counter.

(c) <u>Area Raid Plaque</u> see appropriate precis

7. <u>Raid Plaque Counters</u>

(a) Identification

(1) 

Hostile - black letter on yellow background, magnetic base

(11)  Unidentified raid after raid recognition action. Black letter on yellow background

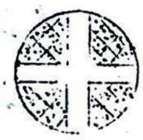
(111)  Allied - white letter on red background

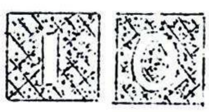
(1V)  Fighter - white letter on red background

(V)  Mixup - black letter on yellow background

(b) Strength

(1)  White letter on red background, magnetic base

(11)  Plus counter - white on dark background, magnetic base

(c) Height  White numerals on black background

(d) Speed

See appropriate Precis

(e) Jamming Indicators

See D.R.W. Precis

Fighter Screen

White arrow with black No on tail denoting cabin 1-6. ~~N.B.~~ White arrow with M on tail controlled by FM.
Target yellow black No on tail cabin controlling interception.
Combined yellow stripe on head of [illegible]

Height on filter :- 1, 2, 4, 6, 8, 10,
Numbers of A/C — 1 2 3+ 6+ 9+ 12+
aircraft

Non directional		directional	
CH —	(N) Roman.	None.	
Type 80,	(80).		Dots.
FPS - 3.	(F)	(5)	Numerals
FPS - 3 upper band.	(F)		Plain
Type 7.	(7)	(5)	Numerals.
CEW, 14 or 8/9	(W)		Dots.
CEW 14 or 8.	(8)		Plain.
CEW; 14 or 9.	(9).	IIII	Bars.
CHEL.	( ).	IIII	bars.
Type 54	( )	IIII	

Bars	Dots	Numerals	Plain
CEW 14/9	80.	FPS 3	FPS 3
CHEL	CEW 14, 8/9.	Type 7.	CEW 14 or 8.
Type 54.	~~CEW~~ 14/9.		

AREA RAID REPORTING.

"Limited" Area Raid Reporting.

"Limited" Area Raid Reporting may be initiated by the Senior Duty Supervisor at the Reporting Unit (Radar Supervisor at Track Telling Rooms.) "Limited" area raid procedure is th be interpreted as the plotting of groups of aircraft by single tracking technique. This technique is to be used immediately that:-

(a) The reporting of a group of aircraft by individual plots will result in delay and therefore loss of early warning of the strength and type of threat.

(b) Reporting landline capacity is threatened either at the reporting unit or the C.F.P.

(c) A possible area raid is detected by long range FPS-3 equipment at the intermittent paint stage as described in paragraph entitled "Grouping of long range tracks by FPS-3 stations."

It is to be understood that the Filter Controller may order area raid filtering of groups of individual tracks being plotted by a reporting unit or of individual groups reported by "limited" area raid technique in order to maintain the highest telling rate from his C.F.P. to G.S.M's and to present to the S.O.C. the shape and/or density of the threat.

The object of the area raid technique is to present each part of the general air threat in broad detail to the Identification and Control authorities at the earliest moment possible so that the necessary number of fighters may be scrambled to intercept with the least possible delay.

Immediately "limited" area raid reporting has been adopted by a radar station, the station supervisor is to pass a brief verbal description of the type of activity forming each "limited" area raid, to the Filter officer. He is to pass the disposition of the aircraft of each group (e.g. "stream", "line Abreast", "box" or "vee",) the strength and the approximate spacing of the aircraft within the group.

RADAR STATION PROCEDURE.

Initial plot.

In all cases where a radar station detects a group of aircraft the initial plot is to be passed by "limited" area raid procedure, that is, single tracking technique. It may be possible to pass a direction wich this initial plot. The position of the plot so passed is to be the mean plot at the centre of the leading edge of the group as indicated by "X" in Fig.1.

Area raids are grouped in the following formations:

1 Stream

2 Line abreast

3 Box

4 Vee (V)

Fig. 1 illustrates the formation layout.

The strength of each group is also to be told and the direction if apparent. When the direction is not apparent at the time of telling the initial plot, the second plot on the raid, which will be the first directional plot, is also to be the mean plot at the centre of the leading edge of the raid.

At this stage the supervisor is to pass the type of raid as indicated above.

If the filter officer requests individual plots upon tracks grouped by the station to form a limited area raid, this request is to be complied with immediately. In this connection, since the direction of the raid will already be known, the information to be passed will be a "Georef" plot on each track, together with the height on each plot if this is available.

FULL AREA RAID REPORTING.

Station Supervisors are not to adopt "full area" raid reporting unless:-

(a) Ordered to do so by the Filter Controller

(b) they have requested permission to do so and this has been granted.

STREAM ATTACK ON A NARROW FRONT.

The leading edge and trailing edge are to be told together with the strength and upper and lower heights. The telling is to be prefixed "Stream", e.g. "STREAM - LEADING - MIKE FOX ONE TWO THREE FOUR - TRAILING MIKE FOX FIVE TWO THREE FOUR.

LINE ABREAST ATTACK PATTERN.

The northerly and southerly or easterly and westerly extremities of the raid are to be told to the C.F.P.C. together with the direction. in which the raid is proceeding. The telling is to be prefixed by the word "ABREAST". Where the disposition is North/South, the Northern extremity is to be told first, where the disposition is East/West, the Easterly extremity is to be told first. e.g.

(a) ABREAST	NORTH	MIKE FOX	ONE ZERO FIVE ZERO
	SOUTH	MIKE FOX	ONE ZERO ONE ZERO
	DIRECTION WEST.		
(b) ABREAST	EAST	MIKE FOX	FIVE ZERO ONE ZERO
	WEST	MIKE FOX	ONE ZERO ONE ZERO
	DIRECTION NORTH.		

BOX ATTACK.

This is to be defined as any group or mass of aircraft not suitable for display in "stream" or "line abreast" pattern, the shape of which can be displayed by four corners. Such raids are to be told by the leading corner or corners first, in clockwise rotation, as shown in Fig 2.

The telling is to be prefixed by the word "Box" and the direction in which the raid is proceeding is to be told. e.g.:

BOX	CORNER ONE	MIKE FOX	ONE TWO THREE FOUR
	CORNER TWO	MIKE GEORGE	ONE TWO THREE FOUR
	CORNER THREE	NAN GEORGE	ONE TWO FOUR ZERO
	CORNER FOUR	NAN EASY	TWO TWO FOUR ZERO

The telling procedure indicated above is to be followed by the ancillary information and track designation which is to be interjected by the continuity plotter.

HEIGHT INFORMATION.

Where a "limited" area raid is dispersed in height and the height difference between tracks or groups of tracks is substantial, it is desirable to form separate tracks for each height where possible, even though the plan position may be identical for each group.

With "full" area raid reporting, the "upper" and "lower" heights are to be passed over the plotting line, but when the main bulk is at intermediate height and/or dispersed very high flyers above the raid, the Filter Officer is to be advised over the liaison line. Any sudden changes of height are to be reported.

-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-

"LIMITED AREA RAID"

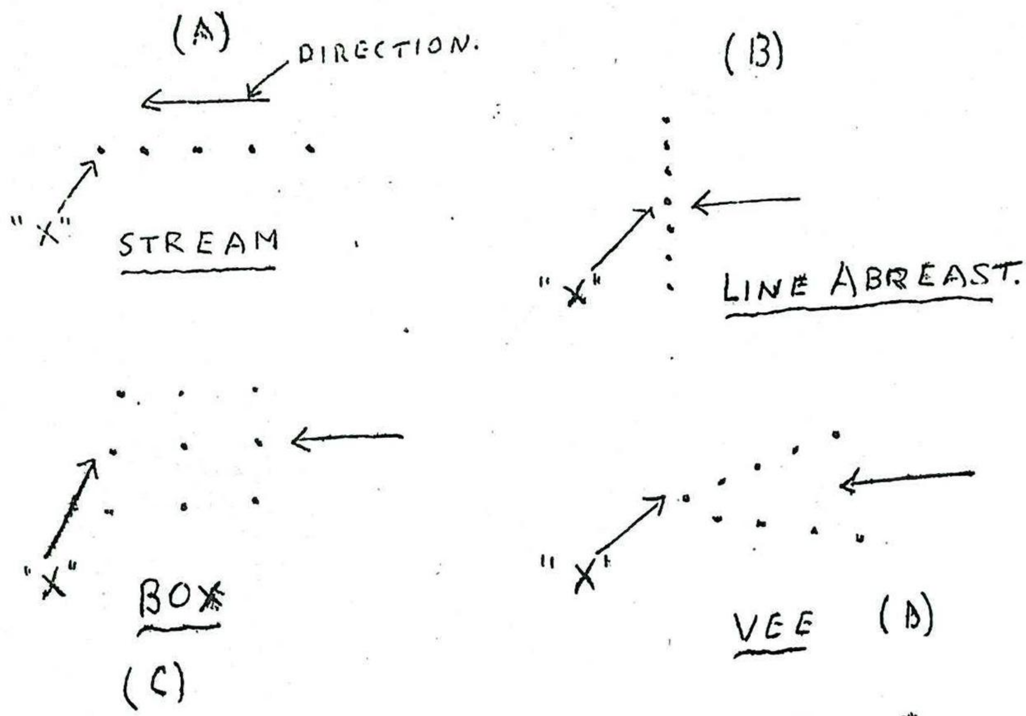


FIG I

"FULL AREA RAID"

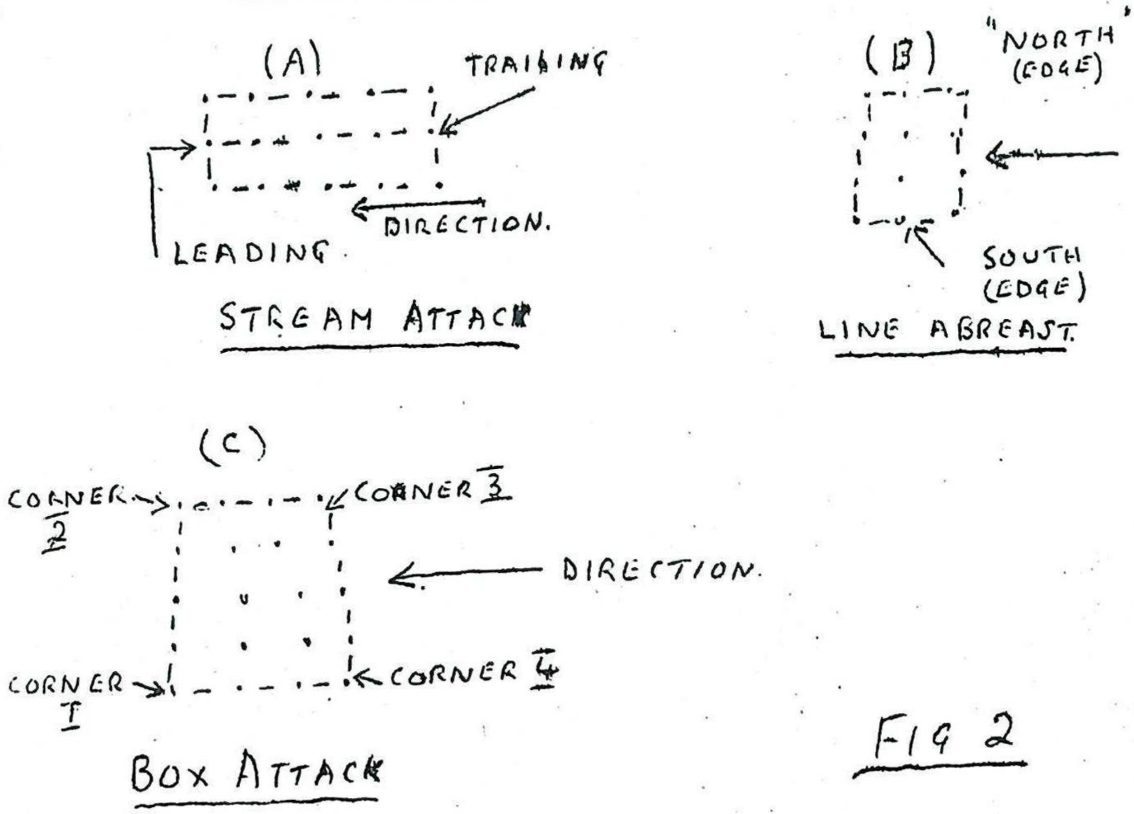


FIG 2

16

SPEED ASSESSMENTS OF LONG RANGE HOSTILES AND X-RAIDS

It is necessary for the controller and the executives at the S.O.C. to have an idea of the speed of raids which may have to be intercepted.

At the Filter Centre a speed orderly is employed equipped with a nautical mile ruler calibrated to the scale of the table map. The following is the procedure he uses;-

(1) Measures the distance covered by the track between two or more plots with the rule.
(2) Checks the time taken to cover the distance measured with a stop-watch accurately.
(3) By using a speed calculator, assessing the track as follows;-
    Up to 350 knots - White speed
    Over 350 knots - Red speed
(4) Places an appropriate coloured ½" magnetic counter on the raid plaque of the track concerned.

A speed orderly is also employed at F.P.S.3 stations, TYPE 80, When a plotter receives speed information from a F.P.S.3 station he is to place the appropriate coloured counter on the raid plaque of the track concerned.

FPS.3, Type 80 & CFP.

, DISPLAY OF SPEED ASSESSMENT OF UNIDENTIFIED "X" AND HOSTILE RAIDS

G.S.M.

In order to display speed information broadcast from Filter Centres, at S.O.C., the same colour code as the Filter Centre is used (up to 350 knots - white speed, over 350 knots - red speed).

The yellow background on the prefix letters "H" and "X" is retained but the letters themselves are coloured white or red, heavily outlined in black to indicate the speed.

When the track is unidentified, i.e. a serial number only has been allocated, and a speed is received from the Filter Centre, a plain disc of the appropriate coloure is placed on the identification space and is changed for the appropriate coloured identification plaque when identification is received.

If such a serial is identified "Allied" then the plain speed plaque is removed when the identification "Allied" is placed on the track.

Upon receipt of the speed colour the G.S.M. plotter calls for the appropriate identification letter in the following manner:-

(1) Serial ---- Red or white as the case may be.
(2) "X-raid Red" or "X-raid White", and places it in front of the serial number.

REPORTING OF RADAR SERVICEABILITY STATES

TO C.F.P.'S AND AIR DEFENCE OPS. CENTRE

1. C.F.P.'s are responsible for passing the Sector Radar serviceability states at intervals of 4 hours to the A.D.O.C.

2. The serviceability state is to be passed to the A.D.O.C. at the following Greenwich Mean (Zebra) Times:-

0600 hours
1000 hours
1400 hours
1800 hours
2200 hours
0200 hours

3. In addition, any change in the serviceability state of a Radar station is to be passed as the change occurs.

4. In both cases the report by the C.F.P. is to cover units afflicted by (a) technical or other serviceability e.g. aerial locked against wind, (b) reduced power and (c) maintenance periods. The serviceability state is to be in respect of both reporting and control channels at each station, and is to discriminate both between control and reporting consoles (when unserviceability of the channel is due to console failure) and radar head failure. In the later case both control and reporting facilities of the particular radar type are to be reported as unserviceable.

5. At beamed radar stations the radar supervisor who is responsible for reporting to the Filter Officer is also responsible for reporting the serviceability of control channels in a form which will satisfy the requirements of paragraph 4 (see above).

For reference these supervisors are as follows:-

(a) Multiple Stations - Console Supervisor
(b) Independent F.P.S.3 Stations - Watch Supervisor
(c) Independent C.H.E.L. " - Watch Supervisor
(d) Independent C.E.W. " - Watch Supervisor
(e) C.H. Stations - Watch Supervisor

6. All radar station track telling rooms are to maintain a serviceability tote adjacent the Radar Supervisors keyboard.

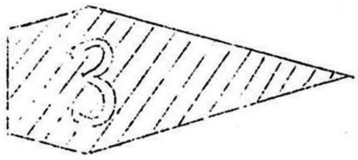
7. Radar stations are to notify the C.F.P. of the radar serviceability state immediately upon opening watch, and of any change throughout operations.

8. C.F.P. reports to the A.D.O.C. are to be made within the ordinary watch or keeping hours of the Sector concerned, but during exercises or in emergency. Reports are to be forwarded over each 24 hour period.

DEFENSIVE RADIO WARFARE

EQUIPMENT

Station D.R.W. Plaque



Station Type	Colour Code
C.H.	Siganl Red
F.P.S.3	Black
Type 7	Light French Blue
Type 14	Grass Green
Type 80	Yellow
Type 54	White

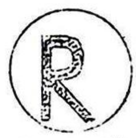
Figures 1 to 3 are used to indicate radar jamming in accordance with the undernentioned grading.

(a) Grade 1 Jamming pressent but not within station plotting area, or if within, not affecting operations.
(b) Grade 2 Jamming present within plotting area and causing loss of information.
(c) Grade 3 Saturated within plotting area.

D.R.W. Counters - (Plastic) C.F.P.

H2S Plot
(White on Black)

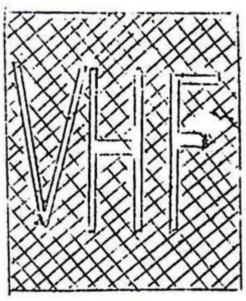
V.H.F.
(White on Black)



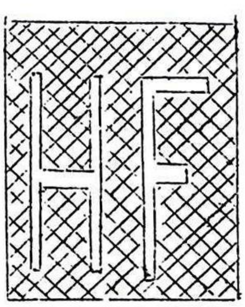
Radar Plot
(Black on White)

D.R.W. V.H.F. Plaques

White on Black
(small magnetic disc on base underside)

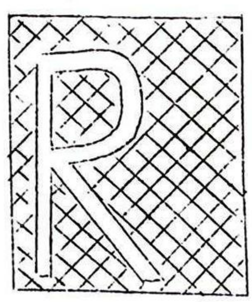


White on Black



D.R.W. Radar Plaque

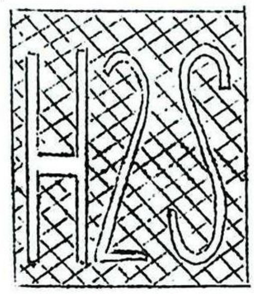
White on Black
(small magnetic disc on base underside)



White on Black

D.R.W. H2S Plaques

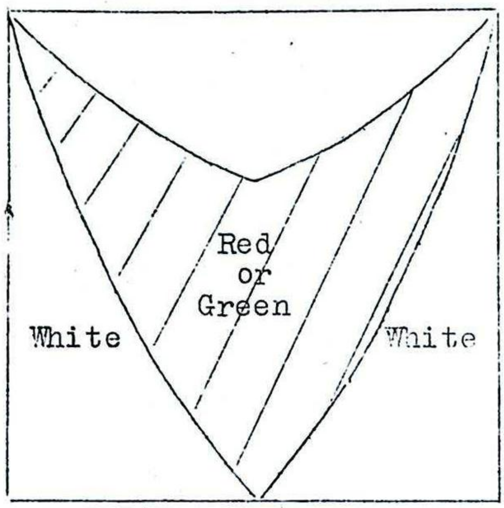
White on Black
(small magnetic
disc on base underside)

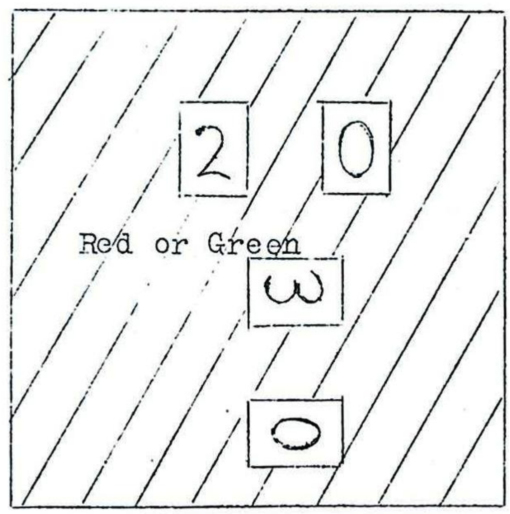


White on Black

Window

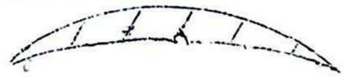
Window Plaques





Red (Centrimetric) Green (Metric)

Window Plotting Counters



Red or Green

24.

GRADES OF JAMMING.

1. RADAR STATIONS.

There are three grades of Radar Jamming:-

(a) GRADE 1.

Jamming present but not within the station plotting area, or if within, not affecting operations.

(b) GRADE 2.

Jamming present within the plotting area and causing loss of information.

(c) GRADE 3.

Saturated within the plotting area.

2. V.H.F.

Two grades of jamming are used in connection with R/T communicatioms namely:-

(a) GRADE 1.

Jammed but working through.

(b) GRADE 2.
Saturated.

RADAR JAMMING REPORTING.

The P.P.I. observer is to notify the Supervisor immediately the first indication of R.C.M. (Radio Counter Measures) or Jamming is displayed. He is to tell the information over the plotting line, giving the mean main bearing to the nearest of the eighth cardinal point of the compass, in the following order:-

S T J G D
Station -Type - Jammed - Grade - Direction.

e.g. Hope Cove - C.H.B.- JAMMED - GRADE 1 - NORTH EAST.

The grading of the jamming is to be reported as indicated under the heading "Grades of Jamming". All changes of direction and grading are to be passed over the plotting lines thus:-

e.g. CHANGE - HOPE COVE - C.H.B. - JAMMED - GRADE 2 - EAST.

When the P.P.I. is clear of jamming, this fact is to be reported over the plotting lines thus:-

HOPE COVE - C.H.B. - CLEAR OF JAMMING.

REPORTING OF"WINDOW"

"Window" is reported by type, depending on the type of Radar equipment being jammed. Window which affects Centimetric Radar Equipment (Type 14) etc. is termed GREEN window. That which affects metric Radar (Type 7) is termed RED window.

When an aircraft commences to drop window, this fact is to be reported as a suffix to each plot until dropping ceases.

Example.
NORTH MIKE FOX ONE ZERO TWO ZERO ONE RED WINDOW.

The direction of drift is to be passed as soon as this can be assessed - RED WINDOW MIKE FOX DRIFTING EAST.

GRADES OF JAMMING (Cont.)

Areas of window which have been dropped are to be passed by up to four GEOREF points defining the area obscured, the order in which these points are told being clockwise from the first. After the first definition of the area of "dropped window", further definition is to be told only:-

(a) When there is a substantial change in the shape or size of the obscured area. or

(b) When required by the Filter Officer.

EXAMPLES.

(1) RED WINDOW STREAM POINT ONE MIKE FOX ONE ZERO TWO ZERO POINT TWO MIKE FOX FOUR ZERO TWO ZERO.

(2) RED WINDOW AREA POINT ONE MIKE FOX ONE ZERO TWO ZERO
POINT TWO MIKE FOX ONE ZERO FOUR ZERO
POINT THREE MIKE FOX FOUR ZERO FIVE ZERO
POINT FOUR MIKE FOX FIVE ZERO ZERO ZERO

When window clears, this is to be reported as follows:-

Red (or Green) Window clear in MIKE FOX.

-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o

REPORTING OF V.H.F. JAMMING.

C.H.B. Supervisors are responsible for the arrangements for telling V.H.F. Jamming to the C.F.P.

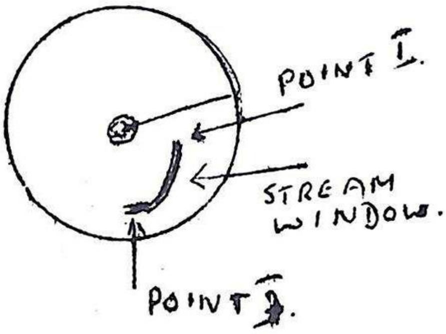


FIG I

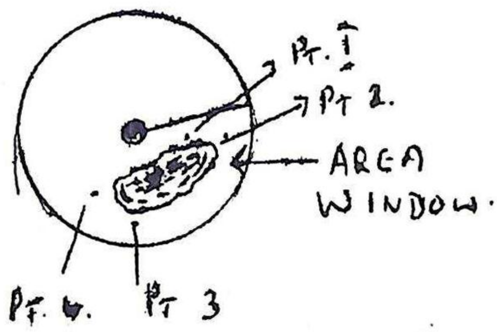


FIG 2.

G E O R E F .

The Georef system divides the earths surface into quadrangles, the sides of which are specific arc lengths of Latitude and Longitude. Each quadrangle is identified by a lettered code in such a way as to avoid ambiguity. The system and code are as follows:

(a) 15° Quadrangles or "Primary Areas" (Fig 1)

(i) There are 24 Longitudinal zones each of 15° width, extending around the globe. These are lettered A to Z inclusive, eastward from the 180° meridian (see note).

(ii) There are 12 bands of latitude each of 15° depth around the globe. These are lettered A to M inclusive northward from the south pole (see note)

(iii) The earth's surface is thus divided into 288 PRIMARY AREAS each identified by two letters, the first letter being that of the longitudinal zone, the second that of the latitude band.

(b) 1° Quadrangles or "Secondary Areas" (Fig 2) Each 15° quadrangle is subdivided into:-

(i) 15x1° zones of longitude, each zone lettered from A to Q inclusive, west to east (see note)

(ii) 15x1° zones of latitude, each band lettered from A to Q inclusive, south to north (see note)

A secondary area anywhere on the earths surface can be identified by four letters. The first two letters referring to the priary area , the third that of the 1° longitude zone, the fourth, that of the 1° latitude band.

(c) Four Figure Reference. (Fig 3) To obtain a four figure reference:-

(i) Each secondary area is subdivided into 60 minutes of longitude, numbered from west to east, and 60 minutes of latitude numbered from south to north.

(ii) The first two numerals of the reference are the numbers of minutes from west to east within the secondary area, the last two numbers of minutes from south to north within the secondary area.

NOTE: The letters I and O are omitted from the code to avoid confusion with figures.

ACCURACY OF GEOREF POSITIONS. A Georef position is accurate to within ONE NAUTICAL MILE when four letters and four numerals are quoted.

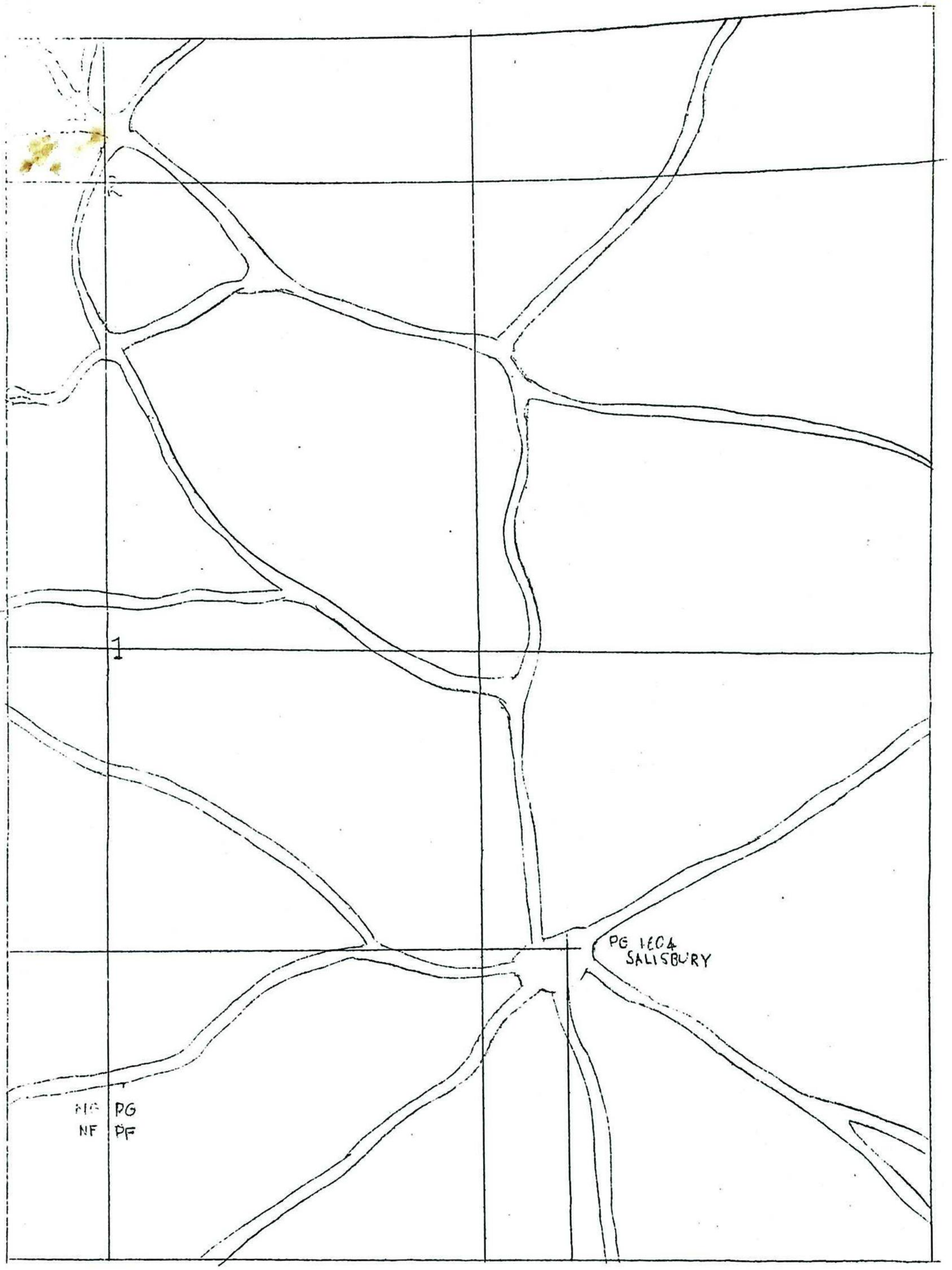
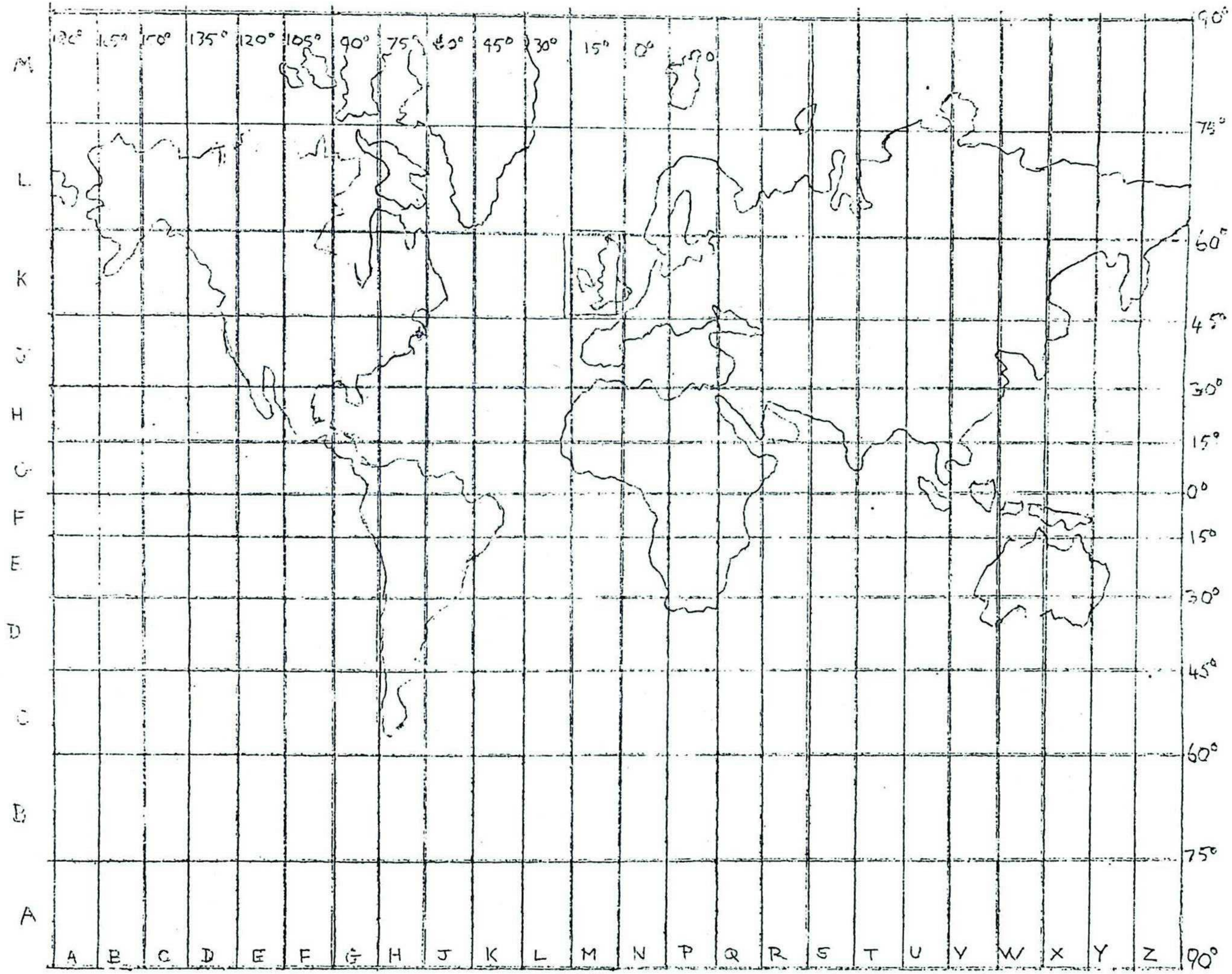


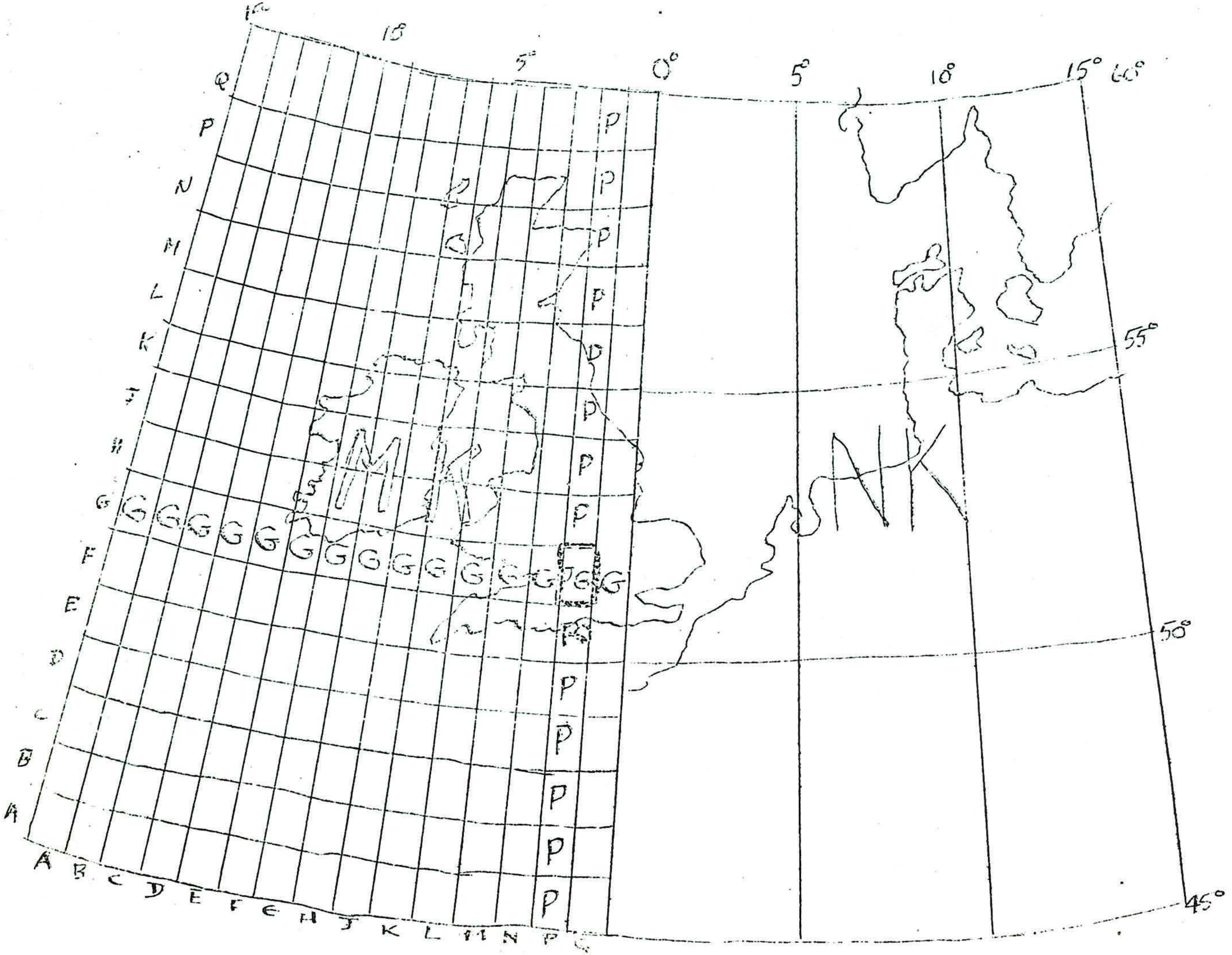
FIG 3



135°
120°
105°
90°
75°
45°
30°
15°
0°
90°
75°
60°
45°
30°
15°
0°
15°
30°
45°
60°
75°
90°
M
L
K
H
F
E
D
B
A
A B C D E F G H J K L M N P Q R S T U V W X Y Z

FIG 1

FIG 2



18

CONTROL OF AMERICAN 75mm SKYSWEEPER A.A.GUNS.

INTRODUCTION.

1. This instruction details the methods and procedures for the control of American 75mm SKYSWEEPER Guns.

LEVELS OF CONTROL.

2. (a) THE SECTOR CONTROLER issues orders regarding the control of American A.A. Guns.

(b) THE AIR EXECUTIVE is responsible to the Sector Controller for briefing the aircrews on the American A.A. Gun States prior to Take off.

(c) THE CONTROL EXECUTIVE is responsible to the Sector Controller for tactical control of fighters and specifically for ensuring that G.C.I. Stations and Sector Fighter Marshals are informed of the orders for control of American A.A. Guns.

(d) THE AMERICAN LIAISON OFFICER is responsible to the Sector Controller for implementing the Sector Controller's directions on the control of American A.A. Guns.

FIRE CONTROL ORDERS.

3. (a) The basic gun state is to be "GUNS FREE" for the engagement of visual targets only, otherwise "GUNS TIGHT" is to apply. Subsequent states are to be as ordered by the Sector Controller from time to time depending on the prevailing air Situation.

(b) Control orders in force are to apply to all heights.

(c) Skysweeper guns deployed in the several areas are to be grouped to form G.F.As. Brize Norton, Fairford, Upper Heyford and Green Common to be known as BRIZE NORTON G.F.A. Lakenheath and Mildenhall as LAKENHEATH G.F.A.

Bfug Dim.

FAILURE OF COMMUNICATIONS.

4. Should communications fail:-

(a) S.O.C. to A.A.O.R. control orders are to be passed via the Liaison Officer at the C.F.P. of the concerned Sector to the A.A.O.R.

(b) C.F.P. to A.A.O.R. early warning situation reports and control orders are to be passed by the S.O.C. Liaison Officer to the A.A.O.R.

(c) S.O.C. and C.F.P. to A.A.O.R. guns revert to the basic state of "GUNS FREE" FOR THE ENGAGEMENT OF VISUAL TARGETS ONLY.

CONTROL OF FIRE ORDERS.

5. (a) GUNS FREE. An order used to indicate that fire may be opened on all aircraft NOT recognised as friendly.

(b) GUNS TIGHT. An order used to indicate that fire may not be opened on any aircraft unless that aircraft is eecognised as hostile and fire will not be directly endanger friendly aircraft.

(c) HOLD FIRE. An emergency order used to indicate that guns may NOT fire UNDER ANY CIRCUMSTANCES, regardless of enemy action until the order "CANCEL HOLD FIRE" is received

(d) CANCEL HOLD FIRE. Guns revert to the gun state in force prior to the imposition of "HOLD FIRE".

Examples :- (a) "GUNS TIGHT BRIZE NORTON"-"GUNS TIGHT BRIZE NORTON"

(b) "GUNS FREE LAKENHEATH" - "GUNS FREE LAKENHEATH"

(c) "HOLD FIRE BRIZE NORTON" - "HOLD FIRE BRIZE NORTON"

cont/

Examples cont. (d) "CANCEL HOLD FIRE BRIZE NORTON" - "CANCEL HOLR FIRE BRIZE NORTON"

Note. The control order in force will apply to all heights.

6. DISPLAY OF CONTROL ORDERS, At the affected S.O.C.s and G.C.I. Stations, the gun state is to be indicated by a removable coloured plaque placed on a small board on which is painted the name of the G.F.A. The board is to be suitable positioned on or near the tote. The coloured plaques indicate gun states as follows:-

GREEN / RED	RED	GREEN	H.F. on GREEN
Indicates Basic State of "GUNS FREE" for visual Targets only, Otherwise "GUNS TIGHT".	Indicates "GUNS FREE" all heights for visual and unseen targets..	Indicates "GUNS TIGHT" all heights for visual and unseen targets.	Indicates "HOLD FIRE" all heights for visual and unseen targets. WHITE letters on GREEN background.

READ IT, REMEMBER IT AND KEEP IT TO YOURSELF.

18

CONTROL OF BRITISH LIGHT ANTI-AIRCRAFT ARTILLERY.

INTRODUCTION.

1. The emgagements of targets by Light A.A. Artillery are based on a system which provides for the recognition of aircraft being carried out by Observation Posts deployed in a ring round a Vulnerable Point (V.P.) A surveillance radar is employed at each V.P. to give local warning. It is NOT able to give identification. It is envisaged that aircraft attacking the V.P. would cross the L.A.A. Observers and that recognition would be reported back to the guns.

2. It is realised, however , that definite recognition may not always be possible, and at the same time, it is considered that the rules under which guns may open fire may have to vary according to the circumstances.

3. Owing to the limited handling capacity of the C&R System and the inevitable presence of large numbers of low flying aircraft in the vicinity of airfields, particularly in the Eastern areas of the Country it may be necessary to restrict guns from firing unless the aircraft is definitely recognised as hostile. Howexer, under certain conditions and in certain areas it might be advantageous to give more freedom to the guns and to releive them of the necessity of making definite recognition. It is envisaged for instance, that such freedom might be given as the basic state of L.A.A. guns defending coastal radar stations against aircraft approaching from the sea, particularly if the enemy adopted the tactics of low level attacks against such stations.

4. The basic state of L.A.A. Artillery generally, is to be "GUNS FREE" Subsequent states are to be as ordered by the Sector Controller from time to time depending on the prevailing air situation. Temporary alterations to the gun states may be ordered by the Commanding Officers of airfields in accordance with paragraph 10 below.

CONTROL ORDERS. (L.A.A.)

5, The following Fire Control Orders are to be used :-

(a) GUNS FREE an order used to indicate that fire may be opened on all aircraft NOT recognised as friendly.

(b) GUNS TIGHT An order used to indicate that fire may NOT be opened on any aircraft unless that aircraft is recognised as hostile and fire will not directly endanger friendly aircraft.

(c) HOLD FIRE An emergency order used to indicate that guns may NOT UNDER ANY CIRCUMSTANCES regardless of enemy action until the order "CANCEL HOLD FIRE" is received.

(d) CANCEL HOLD FIRE guns revert to the gun state in force prior to the imposition of "HOLD FIRE".

Examples:- "GUNS TIGHT NEATISHEAD" "GUNS TIGHT NEATISHEAD"

"CANCEL HOLD FIRE VENTNOR" "CANCEL HOLD FIRE VENTNOR"

NOTE :- The control order in force will apply to all heights.

cont/

LEVELS OF CONTROL

6. THE SECTOR CONTROLLER issues his orders regarding the gun state for all gun defended V.Ps. located within his Sector to the Control Executive, Air Executive and L.A.A. Executive.

7. The CONTROL EXECUTIVE is responsible to the Sector Controller for tactical control of fighters and specifically for ensuring that G.C.I. Stations and Sector Fighter Marshals are informed of the orders for the control of L.A.A. guns

8. THE AIR EXECUTIVE is responsible to the Sector Controller for briefing the aircrews on the L.A.A. STATES prior to takeoff.

9. THE L.A.A. EXECUTIVE is responsible to the Sector Controller for implementing the fire control orders issued.

10. THE COMMANDING OFFICER OF AN AIRFIELD has the right to order "GUNS TIGHT" or "HOLD FIRE" to the guns if he considers the saftety of friendly aircraft in the vicinity of his station are endangered.

(a) To all V.Ps. within five (5) nautical miles from the centre of his airfield.

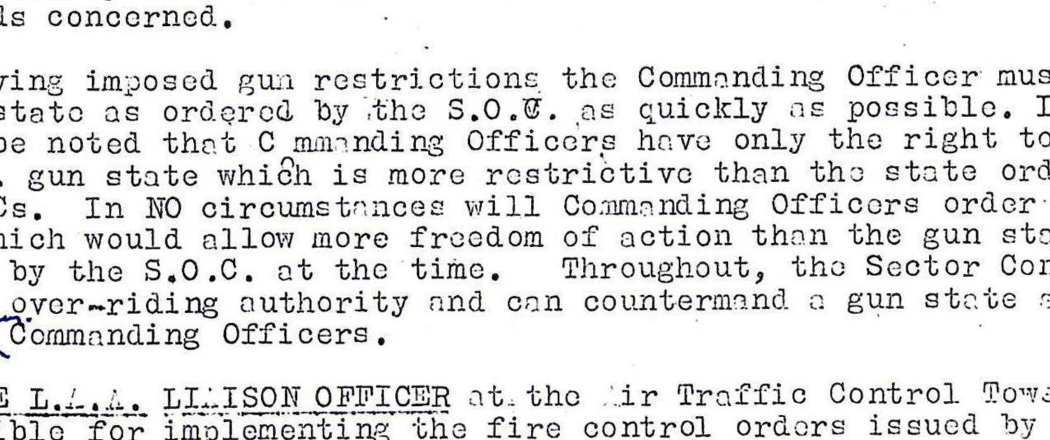
(b) To all V.Ps. up to twelve (12) nautical miles from the centre of his airfield along the approach lane. An approach lane is contained within an arc of 15 degrees from the end of the runway, the centre of the arc being the axis of the runway.

11. Where two airfields are within the distances (specified in para 10above) to one particular V.P. the desired gun state of the V.P. is to be achieved by direct liason between the Commanding Officers of the airfields concerned.

12. Having imposed gun restrictions the Commanding Officer must return to the state as ordered by the S.O.C. as quickly as possible. It should be noted that Commanding Officers have only the right to impose a L.A.A. gun state which is more restrictive than the state ordered by S.O.Cs. In NO circumstances will Commanding Officers order a gun state which would allow more freedom of action than the gun state imposed by the S.O.C. at the time. Throughout, the Sector Controller retains over-riding authority and can countermand a gun state as ordered Commanding Officers.

13. THE L.A.A. LIAISON OFFICER at the Air Traffic Control Tower is responsible for implementing the fire control orders issued by the airfield Commanding Officer.

(9)



L.A.A. GUN STATE DISPLAY AT S.O.Cs. AND G.C.I. STATIONS.

(a) SECTOR OPERATIONS CENTRES.

(i) The GEOREF locations of all V.Ps. within the Sector which are alloted L.A.A. defence are to be shown on the Rats Table by a red painted circle. This will denote the basic state of "GUNS FREE". Should the basic state be altered by the Sector Controller for any reason to "GUNS TIGHT" or "HOLD FIRE" then a suitable disk is to be placed over the red circle. The alteration to the state will be ordered by the Sector Controller through the L.A.A. Executive who will order the Rats Table Supervisor to make the change. The type of disc to be used is shown Below.

(ii) The temporary changes to L.A.A. gun states made by Station Commanders need not be notified to or displayed at S.O.Cs.

(iii) The V.Ps. which cannot be shown on the Rats Table are to be displayed on a small board positioned on or near the Tote.

(b) GROUND CONTROL INTERCEPTION STATIONS.

(i) Similar markings to those at S.O.Cs. are to be painted on Fighter Tables at G.C.I. Stations. Alterations from the basic state to "GUNS TIGHT" or "HOLD FIRE" are to be indicated by covering the Red circle with a suitable disc as mentioned in para (a) (i) above.

(ii) Changes in Gun states ordered by the Sector Controller are to be notified to the Chief Controller by the Control Executive. Temporary changes ordered by Station Commanders of Airfields need not be notified to G.C.I. Stations.

18

A.A. SEARCHLIGHTS AND STRATEGIC SMOKE SCREENS

1. Search lights are deployed with some L.A.A. Guns to enable them to operate effectively at night by illuminating low flying enemy aircraft.

2. Strategic smoke screens are used to efface a vulnerable point or area.

3. Searchlights comply with the L.A.A. Gun Control Order in force unless a special control order is added, e.g. "L.A.A. Guns Tight. Fire".

Strategic Smoke Control orders applied to L.A.A. Guns are not simultaneously effective on Strategic Smoke.

5. Use is made of existing L.A.A. control lines for searchlight control, and of existing L.A.A. and H.A.A. Control Orders. Continuous contact is maintained between

(1) Smoke control centres and the commanders of installations which they are employed to defend, and

(2) Smoke control centres and the nearest A.A.O.R. or L.A.A.C.C.

S.O.C. Order	Action By Searchlight or Smoke
Searchlights Free	Searchlights may expose
Searchlights Tight	Searchlights may not expose
Smoke Free	Smoke may be made
Smoke Tight	Smoke may not be made

Sector Controller Resp for smoke.

18

LIGHT ANIT-AIRCRAFT ARTILLERY

1. Light A.A. guns are designed for use against targets glying below 2,000 ft. They have a high rate of fire and are power operated.

2. Deployment Light A.A. guns are deployed around vulnerable points (V.P.s), e.g. Radar stations etc., or Vulnerable Areas (V.As.) e.g. airfields etc.

3. Observation Posts (O.Ps.) A ring os O.Ps. is sited forward of the outer guns to alert the gun crews and to recognise low flying aircraft. They pass back to the gun positions details of the attacking force (i.e. identity, strengths, directions of approach etc.).

4. Early Warning Early warning is passed to Light A.A. Control Centres (L.A.A.C.C.) (normally accommodated in a vehicle) by a broadcast off the Rats table and G.S.M. at the S.O.C. by the L.A.A. Executive.

5. Control Orders Control orders for use of L.A.A. guns are originated by the Sector Controller, advised by his A.A. Controller and are passed to the L.A.A.C.C. by the L.A.A. executive.

These control orders are transmitted by R/T from the L.A.A.C.C. to the individual guns.

S.O.C. Order	L.A.A. Observation Posts Reports	Action by Guns
(a) L.A.A. Guns Tight Green.	Hostile	Fire unless/until No. 1 subsequently recognises target as friendly
	Doubtful	Do not fire unless target attacks.
	Friendly	Do not fire unless target attacks.
(b) L.A.A. Guns Free Red.	Hostile	Fire unless/until gun No. 1 subsequently recognises target as friendly.
	Doubtful	Fire unless/until gun No. 1 subsequently recognises target as friendly.
	Friendly	Do not fire unless target attacks.
(c) L.A.A. Guns Emergency, L.A.A. "Hold Fire" Order	Hostile) Doubtful) Friendly)	All firing must stop

The Commanding Officer of an airfield defended by L.A.A. has the right to order "L.A.A. Guns Tight" or "L.A.A. Hold Fire" to vulnerable areas and points in the vicinity of the airfield if he considers friendly aircraft are endangered.

19

METEOROLOGY INFORMATION

To carry out their task of tactical control Controllers must always have before them the forecast and existing weather conditions over those areas where the aircraft under their control may fly.

Weather forecasts are obtained from the Meteorological staff and displayed on a weather board on the "Tote" in S.O.C's and G.C.I.'s.

Weather "actuals", that is the weather prevailing at airfields under the control of the sector and other airfields which may be used in case of diversions, are displayed on the airfield states board. Against each airfield is displayed a coloured plaque indicating the serviceability of the airfield. A green plaque indicates the airfield is fully operational, Yellow - Emergency Operational, and Red - Non-Operational. These states may be either due to weather, e.g. low cloud, fog, or to some other cause such as repairs to runways, damage due to enemy attack etc.

The following is a typical example of a weather board at a G.C.I. or S.O.C.

DATE: 1st January, 1955 TIME: 09.00Z

BASE	VIS	CLOUD	WIND	REMARKS	STATE
EXETER	2m	6/8 2,000ft	240/5	Rain	
TANGMERE	200yd	CLEAR	220/2	Fog	
ODIHAM	10m	2/8 8,000	230/8	No Low Cloud	
FILTON	4m	1/8 4,000	290/10		
COLERNE	1m	2/8 2000 4/8 5000	250/12		
YEOVIL	2m	1/8 9500	250/12	Runway Being Resurfaced	
CHIVENOR	1m	1/8 300	220/20	Rain	
LLANDOW	400yd	7/8 100	200/25	Heavy Rain	

DATE: L 1.55 **PERIOD:** 08.00 - 14.00hrs

Height	WIND DIRECTION	WIND SPEED	TEMPERATURE
SURFACE	270	10 knotts	+ 8
2,000ft	260	15 knotts	+ 5
5,000ft	260	15 knotts	+ 2
10,000ft	250	20 knotts	- 1
15,000ft	250	25 knotts	- 7
20,000ft	240	35 knotts	- 12
30,000ft	240	50 knotts	- 20
40,000ft	240	40	- 30

CLOUD: $\frac{7}{8}$ stratocumulus base 2,000ft tops 5,000ft in the West
$\frac{5}{8}$ stratus base between 500ft - 2,000ft in the East

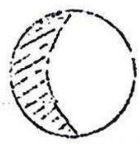
GENERAL INFERENCE: Area of low pressure approaching from the West followed by a cold front expected to reach zone by 12.00hrs.

FREEZING LEVEL: 9,000ft

ICING INDEX: Low

Q.F.F.: 1001 mbs

MOON PHASE



SUNRISE: 07.35hrs

SUNSET: 16.50hrs

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R/T CODE

The following brevity code words are used in fighter control, those marked with an asterisk are the most important and should be learnt first. The remainder must also be learnt, but they are not often used under peacetime conditions.

* AFFIRMATIVE	"Yes" or "Permission granted".
ALOFT	"I have reached my maximum operational altitude".
AMMO MINUS	"I have less than half my ammunition left."
AMMO PLUS	"I have more than half my ammunition left."
AMMO ZERO	"I have no ammunition left."
ANCHOR	Orbit a visible fixed point.
* ANGELS....	"My altitude is .... thousand feet" or "climb to .... thousand feet."
ARK	Airborne lifeboat.
BANDIT	Hostile aircraft.
* BASE	Home airfield
* BENT	Equipment indicated is inoperative or unserviceable.
BIRD DOG	Rescue ship
BLANKET	"I am below cloud" or cloud amount in eigths.
* BOGEY	Unidentified aircraft
BOW-WAVE	A coded meteorological consisting of a series of figures given in the following order:- B - Base of cloud in thousands of feet. O - Top of cloud in thousands of feet. W - Wind, direction to nearest cardinal or quadrantal point followed by speed in knots. A - Amount of cloud in eigths. V - Visibility in miles. E - Extra phenomena, e.g. icing.
BOX-CAR	Heavy bomber.
* BUSTER	Fly at maximum continuous speed.
* CATSEYE	Visual interception at night.
* CHICKEN	Friendly fighter
CLARA	"Radar display is clear of contacts other than those known to be friendly".
* CONTACT	"An echo from the target has appeared on my A.I. or "I can see the target, but carry on controlling".
* CORRECTION	"My last message was incorrect and should have read ....".
CRAMBO	No R/T contact.
DANGER	You are entering a zone of fire from the battery at location indicated.
DAVY JONES	Survivor in sea without a life jacket.
DUMBO	Amphibious aircraft or seaplane used for sea rescue.
EAGLE	Medium bomber.
FADED	"Echo has faded from my radar display".
FAMISHED	"Have you any instructions for me".
FEW	2 - 10 aircraft
FREDDIE	Fighter controlling ship or station.
FUEL	"Amount of fuel remaining is .... gallons (or pounds or minutes depending on type of aircraft).
* GATE	Fly at maximum possible speed (only to be maintained for a short period).
GOODYEAR	Life raft.
GRAND SLAM	All enemy aircraft originally sighted have been shot down.
GRID IRON	"I am experiencing jamming on my P.P.I.".
HEY RUBE	"I need support come to my assistance".
HIGH	Above 35,000 feet.

* JUDY	"I need no further guidance from you at the moment".
JUGS	Fuel tanks.
LEVEL	Enemy is at your altitude (also same height).
LINER	Fly at economical cruising speed.
LOW	Below 10,000 feet.
* MACH NO	"I have reached my comprensibility limits and am not closing with my target".
* MACH YES	"I have reached my comprensibility limits and am closing with my target".
MANY	Eleven or more aircraft
MARK	Aircraft has reached point of patrol
MATTRESS	"I am below cloud".
* MAYDAY	Distress call
MEDIUM	10,000 ft. - 35,000 ft.
* MIDNIGHT	Change from close to broadcast control.
* MORE HELP	I require further guidance from you.
MOTHER	Airfield radar homing beacon or airborne refuelling aircraft.
MUG	External fuel tank.
* MURDER	"I have shot down my target".
MYPOS	"Where am I?"
NEGAT	Cancel or cease.
* NEGATIVE	Not received or no.
* NO JOY	"I cannot see the target assigned to me".
OFF	"Ceasing listening watch on this frequency"
ORANGES SOUR	Weather is unsuitable for mission.
ORANGES SWEET	Weather is suitable for mission.
ORBIT (Port or Starboard)	Circle in the direction indicated and search.
* OUT	Listening out on this frequency, no reply is expected.
* OVER	"The end of my transmission, a reply or acknowledgement is expected".
PANCAKE	Land at base.
PANCAKE AMMO	"I am returning, short of ammunition and wish to land."
PANCAKE FUEL	"I am returning, short of fuel, and wish to land".
PANCAKE HURT	"I am returning, wounded or damaged, and wish to land."
* PEDRO	Rescue helicopter.
* PIGEONS	"Magnetic bearing & distance to base.
PILLOW	Visibility in miles.
* PLAYMATE	Aircraft or boats co-operating on air/sea rescue duties.
POPEYE	"I am in cloud".
PORT	"Turn left on to a heading of .... degrees (magnetic)".
PUNCH	"You should very soon obtain an A.I. contact on the target aircraft".
QUILT	"I am above cloud".
ROGER	"I have received your last transmission satisfactorily".
SAUNTER	"Fly at speed appropriate to maximum enelevance".
* SAY AGAIN	"Repeat your last message".
SKIP IT	Do not attack, cease attack or cease interception.
SKUNK	Enemy or unidentified surface craft.
SOUR	Equipment indicated is operating at reduced efficiency.
SPEED UP	"Increase speed by .... knots".
* SQUAWK	I.F.F. - Mk. 10 - See separate precis.
* STARBOARD	Turn right on to a heading of .... degrees (magnetic).

*STEADY	"I am on prescribed heading" or "straighten out on your present heading".
*STEER	Fly a heading of .... degrees (magnetic) in order to reach base.
*STRANGLE PARROT	Switch off I.F.F. Mk. 10.
SWEET	Equipment aplicated is operating satisfactorily.
*TALLY HO	Target sighted.
*TARGET	Aircraft to be intercepted.
THROTTLE BACK	Decrease speed by .... knots.
*TRADE	Likely enemy activity.
*VECTOR	Alter heading to .... degrees (magnetic).
*WEAPON	A.I.
WHAT STATE	Report amount of fuel and ammunition left.
*WILCO	I have received your instructions and will comply with them.
YELLOW JACKET	Survivor in the water wearing a life jacket.

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R/T CODE WORDS.

CODE WORD	MEANING.
SCRAMBLE	TAKE OFF
VECTOR	ALTER COURSE TO COURSE GIVEN
STEER	SET COURSE GIVEN BY BASE
ORBIT	CIRCLE AND SEARCH
ANGELS	HEIGHT IN THOUSANDS OF FEET
PIDGEONS	THE MAGNETIC BEARING AND DISTANCE OF YOUR BASE FROM YOU:-
PANCAKE	LAND REFUEL AND RE-ARM
BANDIT	IDENTIFIED ENEMY AIRCRAFT
BOGEY	UNIDENTIFIED AIRCRAFT
WEAPON	A.I. SET
BENT WEAPON	A.I. SET UNSERVICEABLE
TALLY HO	AIRCRAFT SEEN AND IDENTIFIED AS HOSTILE
CONTACT	IN CONTACT, HELP STILL REQUIRED
JUDY	NO FURTHER HELP REQUIRED
MURDER	AIRCRAFT DESTROYED
IN THE DARK	YOU HAVE FADED WE CANNOT SEE YOU
ORANGES SWEET	WEATHER IS GOOD
ORANGES SOUR	WEATHER IS BAD
POPEYE	IN CLOUD
QUILT	ABOVE CLOUD
MATTRESS	BELOW CLOUD
WET FEET	OVER SEA
GRAVY	FUEL
JUGS	DROP TANKS
BLANKET	AMOUNT OF CLOUD IN (.) EIGHTHS
PILLOW	VISABILITY IN MILES
V	VISABILITY IN MILES
A VATB	CLOUD AMOUNT IN EIGHTHS
T	HEIGHTS OF TOPS
B	HEIGHTS OF BASE

R/T LOGGING ABBREVIATIONS

WORD	ABBREVIATION
CHECK	CH
CORRECTION	C
NOTHING HEARD	NH
OUT	+
OVER	K
ROGER	R
SAY AGAIN	SA
SEND YOUR MESSAGE	SYM
STAND BY	SB
THAT IS CORRECT	C
TIME	TM
WAIT	W
WILCO	WC
Do you read me.	DUR.
How do you hear me.	HR.
Loud & clear.	LC.
Negative.	NEG.
This is.	DE.
~~Standby~~	~~B~~
Starboard.	STAR.

Do not answer - F.
affirmative - AFFIRM.
acknowledge - ACK.
emergency - Z.
Stand by Pounds - SBW.
Information - INFO.
Silence lifted : SIL LIF.
Speak Slower - SS check
? - RWR check

check & correction
SS & that is correct
RWR.

GLOSSARY OF ABBREVIATIONS USED WITHIN THE C&R SYSTEM.

22

RESTRICTED PRECIS No.C&R/A

A.A.	Anti Aircraft
A.A.L.O.	Anti Aircraft Liason Officer
A.A.O.R.	Anti Aircraft Operations Room
A/B	Airborne
A/C	Aircraft
AE.	Ae rial
A.E.W.	Airborne Early Warning
A/F.	Airfield
A.I.	Airborne Interception Radar
A.J.	Anti Jamming
A.ME.S.	A ir Ministry Experimental Station
A.O.P.	Air Observation Post
A.R.P.	Air Raid Precautions
A.S.I.	Air Speed Indicator
A.T.C.	Air Traffic Control
A.T.C.C.	Air Traffic Control Centre
A.T.C.O.	Air Traffic Control Officer
C.C.	Chief Controller.
C.C.F.P.	Centralised Combined Filter Plot
C.D.	Civil Defence
C.D.L.O.	Civil Defence Liason Officer.
C.D.P.	Combined Directional Plot
C.E.W.	Centrimetric Early Warning
C.H.	Chain Home
C.H.B.	Chain Home Beam
C.H.E.L.	Chain Home Early Warning
C.H.L.	Chain Home Low.
C.M.H.	Centrimetric Heights
C&R.	Control and Reporting
C.R.T.	Cathode Ray Tube
C/S.	Callsign
C.W.	Carrier Wave
D.C.	Deputy Controller
D.R.	Dead Reckoning
D.R.W.	Defensive Radio Warfare
E.T.A.	Estimated Time of Arrival
E.T.D.	Estimated Time of Departure
F.C.	Fighter Command
F.C.U.	Fighter Control Unit
F.I.R.	Flight Information Region
F.M.	Fighter Marshal
G.C.A.	Ground Controlled Approach
G.C.I.	Ground Controlled Interception
G.D.A.	Gun Defended Area
G/S	Ground Speed
G.S.M.	General Situation Map
H.A.A.	Heavy Amti Aircraft(Artillery)
H.P.D.	Horozontal Polar Diagram
H.R.T.	Height Range Tube
HT.	Height
I.A.S.	Indicated Air Speed
I.C.A.N.	International Convention of Aeronautical Navigation
I.F.F.	Identification Friend or Foe
L.A.A.	Light Anti Aircraft(Artillery)
L.R.T.	Long Range Tanks
M.E.W.	Micro Early Warning
M.L.O.	Movements Liason Officer
M.L.S.	Movements Liason Section
P.B.X.	Private Branch Exchange
P.E.	Permanent Echo
P.I.	Practice Interception
P.P.I.	Plan Position Indicator
P.R.F.	Pulse Recurrence Frequency
P.U.T.	Permanent Uninterupted Trunk(Line)
RA.D.A.R.	Radio Direction and Ranging
R.C.M.	Radiocountermeasures
R.D.F.	Radio Direction Finding
R.O.C.	Royal Observer Corps
R.O.C.L.O.	Royal Observer Corps Liason Officer
R.R.O.	Raid Recognition Officer
R.R.U.	Raid Recognition Unit
R.T.	Radio Telephony
RX.	Reciever
S.O.C.	Sector Operations Centre.
S&R.	Search and Rescue
T.A.F.	Tactical Air Force
T.A.S.	True Air Speed.
T.O.O.	Time of Origin
T.P.A.	Track Production Area
T.P.O.	Track Poduction Officer
TR.	Track
U.H.F.	Ultra High Frequency
V.H.F.	Very High Frequency
V.R.B.	Voice Rotating Frequency
W.O.U.	Wireless Observer Unit.
W/T	Wireless Telegraphy

TRADE KNOWLEDGE PROGRESS TEST

U/T FIGHTER PLOTTER.

The questions are knowm as"multiple choice questions" and are the type normally used for trade tests by the Service. Candidates will note that four alternative answers (a,b,c,& d) are given to each question. You are to decide which is the correct answer and put a cross in the appropriate column of the answer sheet to indicate the correct answer. Should you make a mistake, put a circle around the wrong answer and put a new cross in the appropriate square.

1. What is the distance between DE 5959 and DG 5901

(a) 62 n mls. (c) 38 n mls.

(b) 38 st. mls. (d) 60 n mls.

2. An aircraft flying from BB 2527 to CC 2257 would be flying in a ? direction.

(a) N (c) NE.

(b) SW. (d) NW.

3. Numbers on the tail and shaft of an area raid arrow indicate:-

(a) Serial No. (c) Front and depth of raid in nautical miles.

(b) Strength & height. (d) Front and depth of raid in statute miles.

4. An area raid approaching on a narrow front is known as a ? attack.

(a) Stream. (c) abreast.
(b) Box. (d) flood.

5. Who is responsible for authorizing area raid reporting technique,

(a) Filter Officer. (c) Filter Controller.
(b) Filter Supervisor. (d) Radar Supervisor.

TRADE KNOWLEDGE PROGRESS TEST
U/T FIGHTER PLOTTER.

6. An area raid is 'told' from the CFP the following manner:

(a) Area Raid H401 Area 10 by 60 West BG 20. BG 20 9+ at 40

(b) Area Raid H401 West BG 20 BG 20 9+@ 40 Area 10 by 60.

(c) Area Raid 10 by 60 H401 West BG 2205 BG 2205 9+ @ 40.

(d) Area Raid H401 Area 10by 60 West BG 2205, BG 2205, 9+ @ 40.

7. A Red circular disc on a raid plaque at a filter centre indicates that the track:

(a) Has a ground speed of over 250 knots.
(b) " " " " " " 350 "
(c) " an air " " " 350 "
(d) " " " " " under 350 "

8. A speed orderly is employed a t:-

(a) CHEL/CEW Station. (b) FPS3/Type80 Stns, & CFP.
(c) At all RRU's and CFP. (d) At CFP only.

9. A "Rats" track passedmto the CFP from a CHEL station is plotted as a height of:

(a) 500 ft. (b) 5000 ft. (c) 1E (d) RATS.

10. When priority telling is in force, the following is the order of telling:

(a) New incoming raids, H. X. A. F. (b) X.H.A.F.
(c) New tracks, X,H, other tracks fighter only on request.
(d) F.X.H.A.

11. Who is responsible for the accuracy of information displayed on the Mission Tote at S.O.C.

(a) Control Executive. (b) Fighter Marshal.
(c) Air Executive Assistant. (d) Control Executive Assistant

12. Who is responsible for briefing the aircrew on control orders of HAA at S.O.C.

(a) Sector Controller. (b) Control Executive.
(c) Air Executive. (d) Fighter Marshal.

13. Heights are filtered to the nearest:

(a) 1000 ft. (b) 2000 ft. (c) 500 ft. (d) 100 ft.

14. Under normal conditions how many filter arrows should remain on one track.

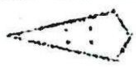
(a) Two (b) Three (c) One (d) Not more than four.

TRADE KNOWLEDGE PROGRESS TEST
U/T FIGHTER PLOTTER.

15. When an H raid merges with an F. tra ck, the filter supervisor should:

(a) Retaim serial number of H raid with prefix M.
(b) Retain fighter serial number with prefix X.
(c) Retain whichever serial number has greater number of aircraft with prefix M.
(d) Retain lower serial number with prefix X.

16. The following plan position counter could be used for the following equipment:



(a) CH (b) CHB (c) FPS3 (d) CEW.

17. The following plotters counter indicates:

(a) Estimated height
(b) Early warning.
(c) Estimated strength.
(d) Exminster.

18. A halma is used to:

(a) Indicate initial filtered position and is coloured in accordance with colour change clock.
(b) Indicate that track has faded.
(c) Indicate initial filtered position and may be of any colour.
(d) Indicate jamming.

19. The figures 091512Z on a Movement Liason Form indicates:

(a) Position and height crossing coast out.
(b) No. of aircraft, height and airspeed.
(c) Estimated time of arrival.
(d) Date/time group of origin of message.

20. Orbitting plots are told by:

(a) A four figure reference.
(b) Four points indicating limits of orbit.
(c) A two figure reference.
(d) Two points indicating North & South limits of orbit.

21. The recorder at a CFP records a track which has faded by the following symbol:

(a) F (b)] (c) D (d) P.

22. In the "GEOREF" Grid System how many secondary areas are contained in aa primary area.

(a) 225 (b) 285 (c) 288 (d) 36

23. RATS Track are passed by R.O.C. tellers to the Filter Centre
(a) Prefix by RATS and heights told as 1, 2, 4.
(b) Without "RATS" prefix and heights told as 1,2,4,
(c) Prefixed as "RATS and heights told as 1E
(d) Without RATS prefix height told as 1E

24. When the Plotter places an F counter against an unidentified track the Filter supervisor :-

(a) Fades the track
(b) Calls the Filter Officer's attention to the track
(c) Calls the Raid recognition Officer's attention to the Track
(d) Places a Fighter identification on the Track upon his own authority.

25. Which one of the following is the main source of Allied aircraft movement for the Riad Recognition Officer

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(a) R.O.C.
(b) A.T.C.C/
(c) Wing Operations Room
(d) A.D.O.C.

C O N F I D E N T I A L

TRADE TRAINING PROGRESS TEST

S.A.C. & Adv. Part I Ftr/Pltrs, Adv. Part II Rad/Ops.

This paper is made up of multiple choice questions. Candidates are to select which they think is the correct answer from the four alternatives A, B, C, & D and put a cross in the appropriate column on the answer sheet against the question number.

1. The serviceability of all squadrons are transmitted to S.O.C.

(a) ½hour before sunrise, and ½hour after sunset.
(b) 2hours before sunrise and 1hour after sunset.
(c) 1hour before sunrise, and 1hour after sunset.
(d) Every 4 hours.

2. Which of the following does not use Form D2?

(a) A.D.O.C.
(b) S.O.C.
(c) Wing Operations Room.
(d) C.F.P.

3. A plain red plaque placed in the identification space of the G.S.M. raid block denotes:-

(a) That the aircraft's speed is greater than 350K.
(b) That it is a 'RATS' track.
(c) That the aircraft's speed is between 300 & 400K.
(d) That the aircraft's speed is less that 350K.

4. The height given in a H.A.A. control order is to take into account a safety margin between the height of A.A. shell bursts and the predicted height of the aircraft flying in that area. This safety margin is to be a minimum of :-

(a) 1000' above and below.
(b) 2000' above and below.
(c) 3000' above and below.
(d) 5000' above and below.

5. Fighter tracks are normally told out from the C.F.P.

(a) After Hostile tracks.
(b) At least once every five minutes.
(c) After all other tracks have been told.
(d) Only at the request of the S.O.C.

6. Naval identification consists of a letter, a figure and a letter. The figure indicates:-

(a) Number of vessels.
(b) Track number.
(c) Identification number.
(d) Serial number.

7. The raid recognition officer at the C.F.P. recieves information on fighter movements from:-

(a) The controlling G.C.I. via the Control Executives Assistant.
(b) The Sector Tote Teller.
(c) The Sector Fighter Identification Teller.
(d) Air Executive.

8. The Squadron States Board is divided vertually into:-

(a) 4 main sections.
(b) 3 main sections.
(c) 5 main sections.
(d) 2 main sections.

9. Individual Formation colours are to be used :-
(a) On the Squadron States Tote for States of Airborne and and Turnaround
(b) On the Squadron States Tote for States of Airborne and ordered to land.
(c) On the Mission Tote only.
(d) On the Mission Tote and the Squadron States Tote for the States of "Airborne" and Turnover.

10. A Plaque in the "Ordered Off" column of the Squadron States Tote shows black figures on Half Green, Half White background Upper Half Green. This denates. :

(a) A.R.IX 18006 Aircraft
(b) Appendix Upper hand Aircraft
(c) Appendix Lower Hand Aircraft
(d) Green Salad Aircraft

11. When the Pilot of an aircraft is in distress, he should prefix his message with the codeword "MAYDAY".

(a) Once
(b) Twice
(c) Tree times
(d) Four times.

12. Which of the following is responsible for briefing aircrews on the position of G.D.A's

(a) Control Executive
(b) Sector Controller
(c) Air Executive
(d) A.A. Controller

13. Ancillary information is told from the C.F.P.

(a) With the initial filtered position and on change
(b) With the first two filtered positions and on change
(c) Height with every position: strength when changed
(d) Height when changed : strength with every position.

14. Speed information is broadcast from C F.P. using a certain telling procedure which of the following is correct:

(a) Ident- direction-plot-ser.No.-strength-height-speed
(b) Speed-direction-plot-Ident-Ser.No.-strength-height
(c) Speed-Ident-Ser.No.-Direction-plot-Strength-height.
(d) Ident-Ser.No.-direction-plot-strength-height

15. When a floodlit type Station is instructed to initiate Area Raid reporting procedure, the C.F.P. plotter displays.

(a) 4 corners & complete ancillary information
(b) 4 corners with track number only
(c) Leading Edge and trailing edge with complete ancillary information.
(d) Leading edges and trailing edge with track numbers only.

16. The four corners of an Area raid displayed on the C.F.P. ~~Table~~ are: CG5050, CG5020, CG3020, CG3050, the general direction North. The correct area arrow to be used for this raid would be :

(a) 30 x 10
(b) 10 x 30
(c) 30 x 30
(d) 50 x 30

17. The D.R.W. teller tells a V.H.F. fix from the D.R.W. triangulation tackle in a certain manner which is correct:

(a) V.H.F. Fix - AB 1234 repeat AB 1234
(b) V.H.F. Fix - AB 1234 repeat AB 1234 Grade I
(c) Voice Fix - AB 123- repeat AB 1234
(d) Very High Frequency Fix AB 1234 repeat AB 1234

18. Jamming information on tracks displayed on the C.F.P. table is told.

(a) With the first two filtered positions and on every change only.
(b) Once every 8 minutes
(c) With each broadcast of the track position
(d) Is not told.

19. The plotter on the fighter table at a G.C.I. receives information from :

(a) C.H.B. Teller
(b) P.P.I. Reader
(c) G.S.M. Teller
(d) C.F.P. Teller.

20 A C.E.W. Station being jammed would be denoted by:

(a) A Red D.R.W. plaque
(b) A Black D.R.W. plaque
(c) A Grey D.R.W. plaque
(d) A Green D.R.W. plaque.

21. Should it be necessary to reposition a track on the C.F.P. table, this will be denoted by :-

(a) A white filter arrow
(b) Any coloured filter arrow
(c) Any coloured heart shaped arrow
(d) Any coloured filtered arrow with a black shaft

22. Responsibility for initiating Area raid reporting rests with the :-

(a) Sector Controller
(b) Filter Controller
(c) Regognition Officer
(d) Filter Officer.

23. Which of the following is not shown on the Forms "B" :

(a) Aircraft type and Mark
(b) Aircraft on hand
(c) Aircraft unserviceable
(d) Aircraft Combat ready.

24. Who is responsible at an S.O.C. for ensuring that G.C.I. Stations and Sector Fighter Marshals are informed of the orders for the control of A.A. Guns. :

(a) Control Executive
(b) H.A.A. Executive
(c) Air Executive
(d) Sector Controller.

25. Sighting Reports are displayed on the Fighter Table as Two types only.

(a) Hostile, or Friendly
(b) Bomber or Fighter
(c) Escorted or Unescorted.
(d) Military or Civil.

26. A GEOREF plan position of four letters and eight numbers will give an accuracy within :

(a) 1 minute of Longtitude
(b) 1 Nautical mile
(c) 10 seconds of Longtitude and Latitude
(d) 6 seconds of Longtitude and Latitude.

27. If an aircraft tracked from BH 5959 to CJ 0101, the direction of the track would be :-

(a) North West
(b) North East
(c) North
(d) South East.

28. An initial directional plot is shown on the G.S.M. by:-

(a) A normal plotting arrow.
(b) A circular Disc
(c) A heart shaped arrow
(d) Two arrows at right angle.

29. Which of the following is the correct procedure for telling an area raid from the C.F.P.

(a) Area raid, mix-up 345, AJ 24 AJ 24. Area six zero by three zero, five zero plus at three zero, direct on West.
(b) Area raid mix-up 345 West AJ 2414 AJ 2414, five zero plus at three zero - Area six zero by three zero.
(c) West Area raid mix-up 345 - Area six zero by three zero AJ 2414 AJ 2414 five zero plus at three zero.
(d) Area raid - mix-up 345 - area six zero by three zero West AJ 2414 - AJ 2414 - fifty plus at three zero.

30. F.P.S. 3 Equipment is essentially.

(a) A short range equipment
(b) A long range equipment
(c) A height finding equipment
(d) A nedium range equipment with height finding facilities.

THE USE OF OPERATIONAL FORMS "A" "B" "C" & "D2" BY AIR DEFENCE OPERATIONS CENTRE, SECTOR OPERATIONS CENTRES AND WING OPERATIONS ROOMS

FORM "A"

Used for all executive orders passed by Air Defence Controllers to Sector Controllers.

Users

(I) Air Defence Operations Centre
(II) Sector Operatios Centres

Procedure

Air Defence Operations Centre

The Air Defence Controller or his Assistant Completes Form "A" at Columns A and B, the contents are then passed by teleprinter to the Sector operations Centre concerned. This may be an initial order or a confirmation of a previous telephone order passed by the Air Defence Controller to the Sector Controller.

Sector Operations Centre

On receipt of a telephone order or a teleprinted Form "A" fromthe Air Defence Controller to the Sector Controller, details of the order are recorded on Form "A". When actioned, the date in Columns C and B is teleprinted back to the Air Defence Centre.

FORM "B"

Users

(I) Wing Operatios Rooms.
(II) Sector Operations Room
(III) Fighter Command Statistical Officer.

Method of Using

Wing Operations Rooms pass by teleprinter or telephone, one hour before sunrise and again one hour after sunset to Sector Operations Centres and to the Fighter Command Statistical Officer, the information required in Form "B"

FORM "C"

Form "C" is used for recording all executive orders issued from Sector controllors to their Wing Operations Rooms.

Method of Using

The Sector Operations Centre is the Sole user of this

FORM "A"

FOR USE IN THE AIR DEFENCE OPERATIONS CENTRE AND SECTOR OPERATIONS CENTRES

Serial No .... Date ....

Order issued by A.D.O.C. (A)	Time (B)	Action Taken (C)	Time Order Completed (D)

Note Columns (A) and (B) are to be completed by the Air Defence Controller or his deputy and Columns (C) and (D) by the Sector Controller or his assistant

FORM "B"

PILOTS AND AIRCRAFT SERVICEABILITY STATE

1. The serviceability of all Squadrons located at each airfield is to be transmitted by teleprinter or telephone to Sector Operations Rooms, one hour before sunrise and again one hour after sunset and at other times when major alterations to existing "State" occur

(x) Serial No ....

(y) Date and Time ....

(A) Squadron No. ....

(B) Location ....

(C) A/C Type and Mark ....

(D) A/C on hand(strength) ....

(E) A/C Combat Ready ....

(F) Crew(s) on hand (strength) ....

(G) Crew(s) Combat Ready ....

S E C R E T

FORM "C"

ORDRES ISSUED BY SECTOR CONTROLLER

SECTOR .... Date...............

A	Serial No.	
B	Order Issued	
C	Time Order Issued	
D	Wing, Squadron, Flight or Section	
E	Time Airborne	
F	Comtrol Station	
G	Time ordered to Land	
H	Time Landed	

States Ordered

J	Standby No. of a/c	
K	Readiness No. of a/c (5Mins)	
L	Available no. of a/c (10 mins)	
M	On Call (30 mins)	
N	Released no. of a/c	
O	Time order completed	

FORM "D2"

OPERATIONAL MESSAGE FORM

Time (A) Date (B)	From/To (C)	Serial No (D)
Information (E)		Remarks (For use of Unit Receiving Only)

SECRET

FORM "A"

FOR USE IN GROUP AND SECTOR OPERATIONS ROOMS

(X) Serial No.................................... (Y) Section / Flight.................................... Squadron....................................

ORDER ISSUED BY GROUP CONTROLLER

To be completed by Group Operations "B.1" and Sector Operations "A."

	T.O.O.
B RELEASED UNTIL....................hrs.	
C AVAILABLE	
E READINESS	
G STAND BY	
J PATROL ORDER ... ... Patrol....................................Feet Intercept enemy raid No...................... Intercept enemy raid approaching	
....	
....	
O IF NOT ENGAGED LAND AND REFUEL	
S OTHER ORDER ISSUED BY GROUP CONTROLLER	

ACTION TAKEN

(A) To be completed by Sector Operations "B."
(B) Transmitted to Group by Teleprinter.
(C) Noted by Group Operations "B."

	(A) Time.	(B) Initial.	(C) Initial.
D AVAILABLE ...			
F READINESS ...			
H STAND BY ...			
K LEFT GROUND			
L ON PATROL LINE			
M ENEMY SIGHTED ...			
P ORDERED TO LAND			
Q LANDED AND REFUELLING ...			
R READINESS ...			
S			

DATE............/............/............

R.A.F. Form 1146.

23476 T. Wt. 49367/4769. 15,000 Pads. 3/40. W. & S. Ltd. 51–6520.

SECRET

R.A.F. Form 1146A

FOR USE IN SECTOR OPERATIONS ROOMS WITH FORM "A"

Date..

(X) Serial No............................ (Y) Section / Flight .... Squadron..

Order issued by Group Controller.		Action Taken.			
			(A)	(B)	(C)

(*9449—8099) Wt. 8716—P8 3,500 Pads 4/42 T.S. 700

SECRET FORM "B."

PILOTS AND AIRCRAFT SERVICEABILITY STATE

The Serviceability of all Squadrons located in a Sector is to be transmitted by teleprinter to ~~Group~~ SECTOR Operations Room ~~at 09.00 and 18.00 hours daily and~~ ONE HOUR BEFORE SUNRISE & ONE HOUR AFTER SUNSET at other times when major alterations to existing "State" occur.

(A) Serial No...

(B) Date and Time...

(C) Squadron No. ....

(D) Aircraft "A" Flight...

(E) Pilots "A" Flight..

(F) Aircraft "B" Flight...

(G) Pilots "B" Flight..

(*10205) Wt. 16828—637 2,000 Pads 8/42 T.S. 700 R.A.F. Form 1147.

SECRET

OPERATIONAL MESSAGE FORM

Form "D" 2

Operational Message received / transmitted by Group Operations Officer / Sector Operations "B"

Time (A)	Date (B)	From/To (C)	Serial No. (D)
Information (E)			REMARKS (For use of unit receiving only)

R.A.F. Form 1149

(*11865) Wt. 52788—4600 5M Pads 4/43 T.S. 700

Wt.42023 3232 50m 2/50 C. & S. Ltd. 51 (26)

SECRET

GROUP__________ DATE__________ SHEET No.__________

RECORDER__________ FILTERER (1)__________ (2)__________ (3)__________ (4)__________

Time	Dirn.	Plot	Raid	No. A/C	Height	Remarks

SECRET

SPEEDO F	PETROL	DATE	No
S	OIL	CAR No.	

TIME	PICK UP 11.	DESTINATION	£	s	d
	1 Secl[illegible] Com.	9			
	2 Air Ex.	7 Every day [illegible]			
	3 Air Ex Ass.	3 [illegible]			
	4 Con Ex.	6 [illegible]			
	5 Con Ex Ass. . 2				
	6 DRW Com.	& with Con Ex Sec [illegible]			
	7 Rail Com.	all Rail			
	8 Sec F [illegible]				
	9 Ant Com	all A/A			
	10 HAA Ex	[illegible]			
	11 LAA Ex.	Plots all A.A. [illegible]			
	12				
	13 Sec. Con Ro. [illegible]				
	14 [illegible] through to [illegible]				
	15 Orders [illegible]				
	16 [illegible]				
	17 Controls smoke				
	18 Inflammable [illegible] Con orders				
	19 Liaison with other Sec [illegible]				
	20 Control of A/C in Sect.				
	21 Safety of A/C in other Sector. Reinforc[illegible]				

TIME	PICK UP	DESTINATION	£	s	d

22 Air Ex Hq To Sec Con for
23 Executes in order of Readiness
24 Diversions to/fro Suplr airfields
25 Tote display on Airfield readiness
26 Briefs air crews at W.T. on current air sit.
27 Passes "scrambles" on.
28 Air sea rescue
29 Liaise with other Air Ex
30
31 Air Ex as Hq To Air Ex for
32
33 Accuracy of To (airfield
34 Maintains Air Ex log
35 Form T.E.
36
37 Con Ex Hq To the Sec Con for
38 Allocate Hts to Raids. Sec Controllers
39 Allocate VHF/RT Channels to
40 ~~Information to [illegible]~~ [illegible]
41 Liaise with other Con Ex. [illegible]
42 Safety of a/c within [illegible]
[illegible] air sit [illegible]

No. 33 E.F.T.S., R.A.F.,
SOLO FLIGHT AUTHORIZATION

Aircraft No. ______________ Date 10 ~~7~~ 5-43

Student Pilot WAC TALL.

Sequences 15. 16. 17. 22

Time of Take-off ~~1700.~~

Duration of Flight 1 Hr. Down by. ~~1800~~

Authorized by E.White. F/Sgt

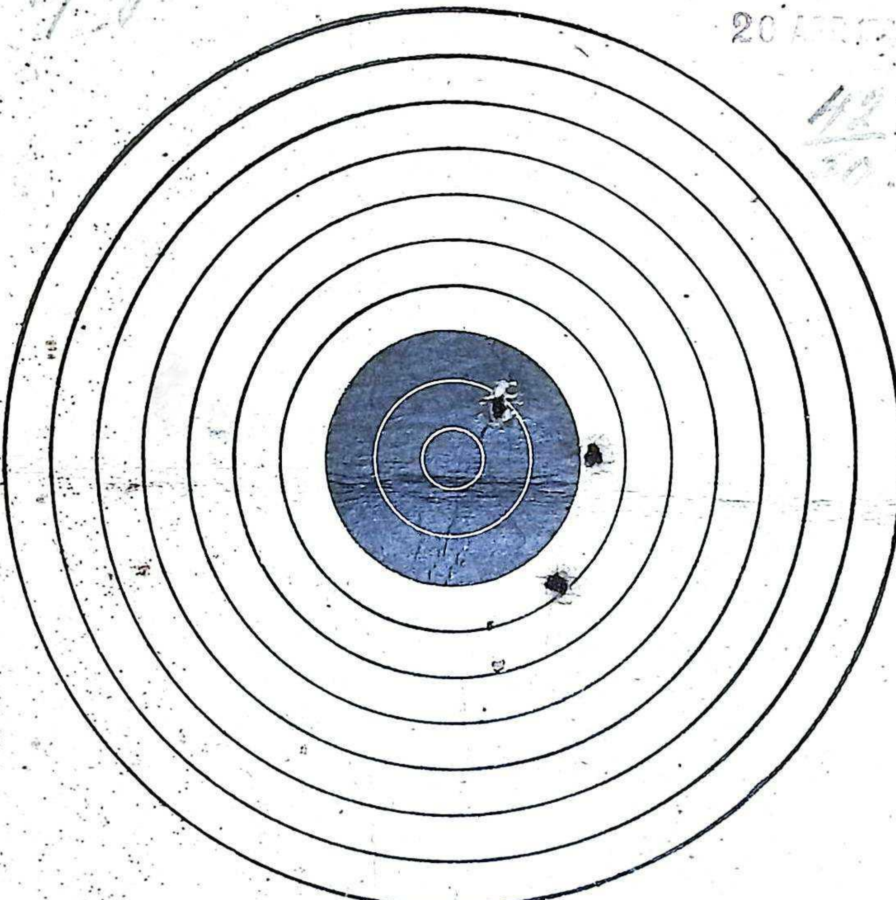
Timekeeper:

Not valid without authority of Flight Commander.

WALLS HILL RIFLE RANGE

F/Sgt. Tall.

200 Squadron.



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PROPERTIES OF WAVES

Since it is convenient to think of the propogation of radio energy in terms of wave motion, we must define exactly what is conveyed by the term "waves".

When a stone is thrown into a pond, ripples spread out in all directions, the ripples being caused by displacement of the surface of the water from its normal smooth condition. The original level of the water in the pond before it was disturbed by the ripples is called the position of "NO DISPLACEMENT".

When the surface of the water is disturbed, a series of crests and troughs appear alternately to move away from the point of disturbance. If a cross section of the displacement of the surface of the water is examined, it will appear as illustrated in Fig. I

Definition of a Wave

"A 'wave' is a progressive disturbance in a medium consisting of alternate stresses and strains without any permanent displacement of the medium in the direction of which the wave is travelling".

Wave Constants

To describe a wave fully certain constants or characteristics are laid down:-

Wavelength

The distance between any two similar points measures in metres or centimetres. It is denoted by the symbol "λ"

Frequency

The number of waves that pass a given point in one second. The frequency is measured in cycles per second (written as "c/s"). It is denoted by the letter "f".

Velocity

The distance moved by a single crest in ONE SECOND. Velocity is denoted by the letter "v" and is measured in miles or metres per second.

Velocity of sound waves equals 1100 ft. per second
Velocity of radio waves equals 186240 miles per second
or
300,000,000 metres per second

Amplitude

The maximum displacement from the line of zero displacement.

Period

The time in seconds for a complete oscillation to occur.

Relation between Wavelength, Frequency, and Velocity

Radio energy travels a certain distance in a given period (e.g. 186340 miles in one second). This distance is termed the wavelength and is a measure of length just as feet and inches are a measure of length. Using the rule DISTANCE equals VELOCITY X TIME, it is found that:-

WAVELENGTH (DISTANCE) equals VELOCITY (SPEED) X PERIOD (TIME)

ELEMENTARY RADAR.

A short History of Radar. The principle of Radar.
The main types of reporting stations.

1929 Sir R.A.Watson Watts starts experiments at Daventry and in 1935 moves to Orford Ness, then to Bawdsey and establishes the first A.M.E.S. (Air Ministry Experimental Station. First C.H. (Chain Home) Station established and from there East Coast covered and eventually the whole coastline around Britain.

THE PRINCIPLE OF RADAR. Short powerful pulses of energy transmitted over a given area. An aircraft in the field of energy will act as a reflecting agent and will cause a certain portion of the energy to be sent back to the receiver. The time interval between transmission and reception is automatically measured, thus determining the range of the reflecting agent.

A good example of the principle involved is to drop a pebble into a calm pool of water and to observe how the ripples radiate from the point of disturbance and on striking a rock or other obstruction reflection is set up.

Similarly, by shouting and awaiting the echo one can by knowing the speed of sound calculate the range of the nearest high land. This principle has been in use for centuries by sailors to check on the position of icebergs.

COVERAGE.

Coverage is the word used to describe the area covered by the transmission of energy from one particular type of Radar Station, or can be used to described the area covered by a series of Radar Stations.

PRINCIPLES OF RADAR

Sound Echo Principle

If you understand the principle of sound echoes, you understand one of the basic theories of Radar.

Suppose a person stands on one side of a valley and shouts. After a small interval of time the echo of the shout returns. In other words, the sound waves from the persons voice travel through the air, hit the side of the hill on the other side of the valley and bounce back. It is this reflected sound wave which is heard. In order to hear it distinctly the duration of the shout must be short, and silence maintained until the echo returns.

The distance between the hill which reflects the shout and the person who shouts can be measured by noting the time that elapses between the original shout and the hearing of the echo. This time could be measured by a stop-watch and knowing the speed of sound (1120 ft. per second), the range can be determined, e.g. If the time elapsed between a shout and the hearing of the echo was four seconds. Knowing that this four seconds is composed of two seconds for the shout to hit the object and two seconds for the echo to return, the distance from the hillside would be equal to 2 x 1100 which is equal to 2200 ft. (See Figure 1).

Radar Echo Principle

(a) Radar also uses the principle of echo or pulse reflection. A strong pulse of radio energy is sent out into space, and if there is an object such as an aircraft or ship in the path of the outgoing energy some of the radio waves upon striking the object rebound just as sound waves do from a hill (and produce an echo). This echo is not heard but relays on a special indicating device called the CATHODE RAY TUBE.

(b) In Radar we do not use sound waves but radio waves which travel at the very high speed of 180,240 statute miles per second, equivolent to 162,000 nautical miles or 3000,000,000 meters per second. These radio waves are generated in a unit called a transmitter which is switched on or activated for a very short period of time, so short that the time is measured in micro-seconds (millionths of a second). This short time during which the Transmitter is sending out Radio energy is referred to as the "PULSE WIDTH" or pulse duration. During this short time the transmitter produces a maximum amount of energy after the pulse has been emitted the transmitter becomes what is know as quiescent for a definite period of time (measured in micro-seconds) before it is active again. This period of time is referred to as the "Rest Period".

(c) It is during this resp period that the echo returns and this period must be of a sufficient curation to allow the echo to return to the receiver. The transmitter is "active" for a certain number of times per second, and this is known as the pulse repetition rate.

Range Determination by Radar - (See Figure 2)

Knowing the speed of radio waves, it is possible to obtain the range of a target by the same method as that used in the case of sound. For example, supposing that the transmitter sent out a short pulse of radio energy, and that the reflected wave is received after 1,000 micro-seconds, the distance to the target and back is:-

$$\frac{1,000}{1,000,000} \text{ X } 186,240 \text{ equals } 186.24 \text{ miles}$$

What you actually do is measure the elapsed time from the instant the pulse is sent out until the reflected wave returns to the starting

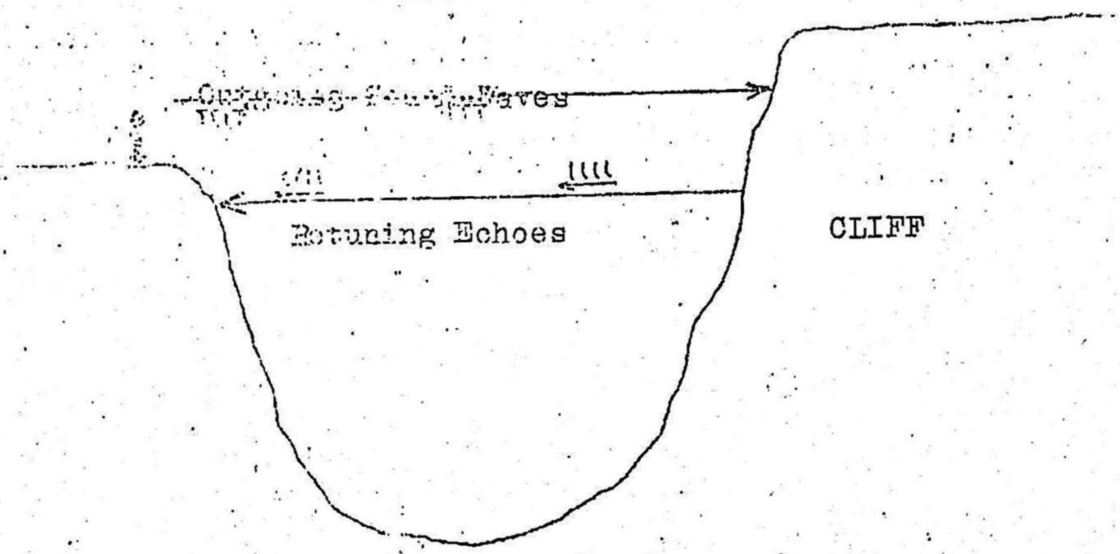
Returning Echoes
CLIFF

Fig. 1

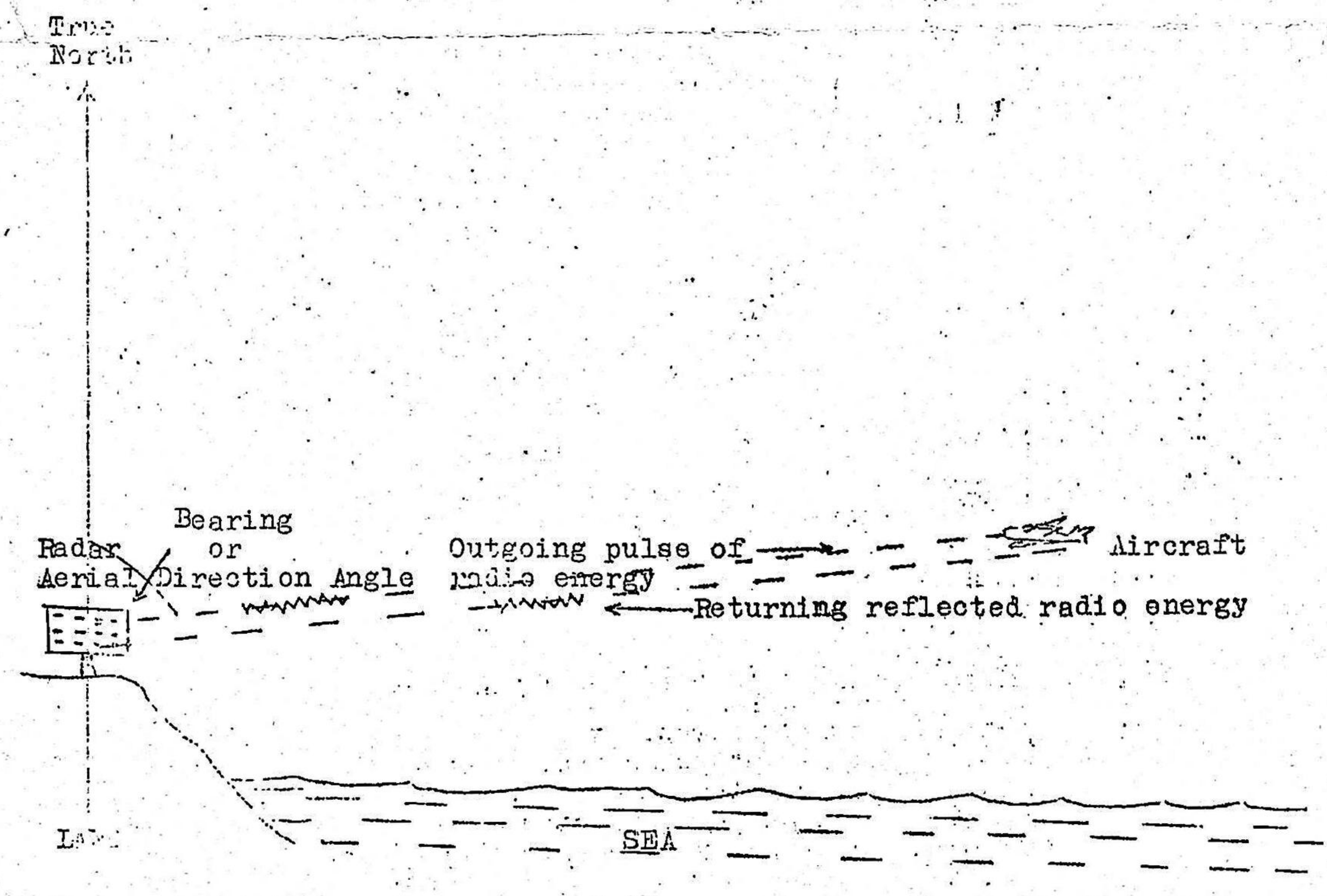
Bearing
or
Radar
Aerial
Direction Angle
Outgoing pulse of
radio energy
Aircraft
Returning reflected radio energy
SEA

Fig. 2

MAGNETISM.

The word magnet is derived from a locality named Magnesia in Asia Minor where a mineral or loadstone (iron ore), discovered by the Ancient Greeks, possessed the property of attracting and repelling certain metals.

Magnetic Polarity.

Everyone is familiar with the toy horse-shoe magnet, so called from its shape. It has the property of attracting iron filings, pins, needles and in fact, any small pieces of iron or steel.

Such a magnet is called a permanent magnet because the attractive force possessed by it is inherent in the magnet itself and does not depend on any external influence. Actually any permanent magnet slowly loses its magnetic properties, the degree to which they are retained depending upon the retentivity of the material of which it is made.

A more convenient form of magnet is the bar magnet which can be made from an ordinary steel knitting needle by stroking it in one direction only with one pole of a permanent magnet. If such a bar magnet is suspended horizontally, as shown in Fig. 2 it will be found to take up such a position that its axis lies approximately North and South. If one end is marked, it will be found that no matter how the magnet is displaced, the same end eventually comes to rest pointing roughly towards the North. The ends of the magnet are therefore called the North seeking end (or "Pole") and the South seeking end (or Pole)respectively.

This pole seeking property is due to the fact that the earth itself is a huge magnet having North and South seeking poles situated near, but not coincident with, the Geographical Poles.

The North seeking pole of a magnet is that which is attracted towards the geographical north region of the earth. If the poles are considered to be positive and negative respectively, the geographical north region of the earth is NEGATIVE POLARITY.

The attractive force of a magnet is most concentrated in the neighbourhood of its poles. This is easily shown by dipping a magnet into iron filings and noting in which regions most filings adhere, as shwon in Fig.1. (See Appendix A attached.)

The mutual action which takes place between magnets can be easily demonstrated. E.g. if the South seeking pole of another magnet is brought near to the South seeking pole of a suspended one as in Fig. 3(a), it will be found that repulsion takes place, while if the North seeking end is presented to it, attraction occurs as in Fig 3(a & b). The first law of magnetism is that:

"Like poles Repel and unlike Poles Attract."

Magnetic Field and Lines of Force.

A permanent magnet is able to move pieces of iron or steel situated some distance away and apparently without any connecting mechanism. The space around the magnet through which its influence can be detected is called a Magnetic FIELD.

Lines of Force.

Place a bar magnet on a table, cover it with a sheet of cardboard and sprinkle it with iron filings. Tap the cardboard gently and observe that the filings fall into a definite line pattern as shown in Fig 4.

The magnetic properties appear to be concentrated in two regions of the magnet termed the North and South poles.

The significance of this iron filin "map" is that it indicated the structural properties of a magnetic field.

By a first guess the magnetic field might be supposed to consist of a mass of irresistable lines of force whose spacial arrangements are revealed when filings are scattered among the, These lines of force are imagined as elastic threads tending to shorten longways and to widen sideways.

The lines of force are regarded as emerging from the north side of a pole magnet and as entering by the south pole after having traversed the surrounding space and converting it into a magnetic field.

If a small light freely suspended magnet is placed in a magnetic field it will move until its axix coincides with the direction of the lines of force of the field. This needle (magnet) has its most important application on the magnetic compass.

The iron filings then enable us to determine the general layout of the lines of force in a magnetic field and the suspended magnetic needle tells us of a direction of the lines of force at any point.

Magnetic Flux.

It may seem far fetched to talk of counting these lines but such a task has been accomplished. The number of lines are feferred to as the "Magnetic Flux. and may be defined as the:-

"total number of lines of force passing through a region of curve" This also describes the strenght of a magnet.e.g. A magnet has 500 lines.

Flux Density.

In general, the effects of a magnetic field are most marked when the lines of force are most closely packed together; the term Flux Density is used to denote the degree of packing, and may be defined as "the number of lines of force which pass through an area of 1 square cm drawn at right angles to the lines of force.

ELECTRO-MAGNETISM.

A Danish Scientist made the important discovery that the space around an active conductor was similar to the space around a magnet; pieces of iron and steel experienced forces, and suspended magnetic needles were deflected while the current was flowing and the effects disappeared when the current was switched off. It is this production of a magnetic field by an electric current which we call its "Magnetic Effect."

Magnetic Field of a Straight Conductor.

The conductor AB in Fig.1.(see App."A"to this precis) is a piece of thick copper wire passing at right angles through a sheet of cardboard. If a current is passed through the wire and at the same time iron filings are sprinkled on the cardboard, it will be seen that the filings fall into a pattern of concentric circles whose common centre is on the axis of the conductor AB. The pattern shows the spacial arrangements of the magnetic field created by the electric current. The lines of force are concentric circles. This type of magnetic field differs from that of a bar magnet in that the lines of force neither converge nor diverge from any particular point and for this reason the field has no regions which behave like poles. In spite of this however, the lines of force will have direction and thus can be determined by placing a small compass on the cardboard when the current is flowing. The compass needle will take up a position as a tangent to one of the concentric lines of force and its South-North direction will give the direction of the lines at that point. **Such an experiment will show that the direction of the lines is related to that of the current in the same way as the direction of turn of a right-handed screw is related to the** direction in which its point moves. These results are indicated in Fig.2. Fig.2(a) illustrates the current flowing from A to B. The direction of the lines of force are anti-clockwise.

In fig 2(b) the lines of force are represented as flowing clockwise. The current in the conductor BA is flowing from B to A.

The standard rule for determining the relation between direction of current flow and direction of the field is that they bear the same relation to one another as the direction of movement and that of rotation of an ordinary corkscrew.

Magnetic Field of a Solenoid.

A Solenoid is simply a coil of wire or a number of continuous loops through which a current of electricity is flowing. Such a solenoid generates a magnetic field not unlike a bar magnet but with the exception that the lines of force pass through the interior. These lines are parallel and evenly spaced. Such a field is termed a uniform field. The end of the coil where the lines of force enter is termed its South Pole; the end from which they emerge being termed the North Pole. Fig 3 illustrates the magnetic field set up by a solenoid.

Tests wigh a compass needle will show that with the current direction as indicated, the directions of the lines of foree will be as shown by the arrows in Fig.3. Since the lines appear to diverge from the left-hand end, that end will behave like a north magnetic pole, and for a similar reason, the right-hand end will behave as a South pole. If the direction of the current is reversed, the polarity of the solenoid reverses also. There are several rules relating the direction of the current with the polarity, two of which are given below:-

(1) If, looking end ways at a solenoid, the direction of the current is clockwise, that end is the South Pole. The rule is remembered by the sketch in Fig.4. It is drawn by describing the letter "S" with arrows at each end and then completing the circle. The arrows indicate the direction of the current around the solenoid, and the "S" denotes the polarity.

(2) Place the right hand over the top of the coil with the fingers pointing in the direction of the current; then the thumb points forward towards the north pole of the solenoid.

Experiments show that the flux created by a solenoid is proportional to the current flowing in the windings. In terms of a formula the flux through a close-wound solenoid can be shown to be:-

$$\phi = \frac{4 \pi N i A}{10\, l}$$

where N = total number of turns
i = current (amps)
A = area of cross-section (sq, cms)
l = length (cms)

This formula shows that it is the product Nxi, or the AMPRE-TURNS which decides the strenght of the flux: thus proving that the magnetic effect may be doubled either by doubling the current or the number of turns, provided A and l are unchanged.

Iron Cored Solenoid.

In the above discussion, the material occupying the inside of the coil was regarded as air. If the core is a bar of soft iron the magnetic effect of the solenoid becomes more powerful. The iron core becomes a magnet when placed in a magnetic field (caused by the current in the solenoid). The core now adds its own "acquired" flux to that of the magnetic field resulting from the solenoid. The total flux resulting from an iron-cored solenoid is equal to the sum of the flux produced by the solenoid and that of of the iron core.

Owing to the lack of retentivity, the iron core loses its magnetic flux as soon as the current in the solenoid is switched off. An iron-cored solenoid is often called an "electro-magnet". It provides a powerful source of magnetism which can be created or destroyed by merely turning a switch.

Retentivity.

It is the property of a substance to retain its magnetism after the magnetic field has been removed.

Permeability.

The abilty of a substance to incease the flux in its immediate neighbourhood.

High and Low Retentivity.

The property of a substance to retain its magnetism for a long (High) or short (Low) period of time.

High Permeability.

The quality of a substance to sbsorb magnetic flux at a high rate, e.g. (Soft Iron.)

Low Permeability.

The quality of a substance to absorb magnetic flux at a low rate e.g. steel.

NOTE. Low Permeability usually gives High Retentivity.
High Permeability usually gives Low Retentivity.

Electro-Magnetic Induction.

The principle of electro-magnetic induction was discovered by Faraday in 1831. By the use of experiments he discovered that when a current is switched on in one closed circuit supplied by a battery, a current will momentarily flow in an associated closed circuit which has no direct power source. When the current in the first, or flowing circuit, is switched off, current again flows momentarily in the associated or secondary circuit, but in the opposite direction.

Fig. 1 shows the experimental equipment as used by Faraday.

An iron ring "R" was provided with two windings of insulated wire; one of these "P" was connected to a battery by means of a switch, while the other, the secondary winding "S", was connected to a sensitive galvonometer.
When the primary circuit was completed by means of a switch, the galvonometer needle showed a deflection. A similar result occurred when the primary circuit was broken, but the deflection of the deedle was in the opposite direction. It was deduced form the experiment that while the primary current was growing, an E.M.F. was set up, or induced, in the secondary, and while the primary current was decaying, E.M.F. was again induced in the secondary, but in the opposite direction.

Since the only connection between the two windings is the magnetic flux generated by the primary circuit and threading through the secondary circuit, the effects are the result of "flux" activity.

The following experiment confirms the "flux" influence.

A Solenoid of many turns is connected to a galvonometer and a permanent magnet is plunged into the coil. While the magnet is in motion the galvonometer needle is deflected, but as soon as the magnet comes to rest the needle returns to zero. As the magnet is withdrawn from the coil similar results are obtained, but the galvonometer deflection is in the opposite direction.

It is clear that with inserting and withdrawing the magnet, the number of magnetic lines threading through the solenoid have set up or induced an E.M.F. in its windings. The same results were observed in the iron ring experiment; switching on the primary current established a magnetic flux through the secondary winding and this change of flux was accompanied by an induced E.M.F.

The magnitude of an induced E.M.F. can easily be seen to depend on the speed at which the inductive action is carried out: the faster the magnet is plunged into the solenoid the greater is the needle deflection. If it is inserted very slowly the deflection is very small, but whether inserted rapidly or slowly, the total flux change is exactly the same: the magnitude of the effect therefore appears to depend on the "RATE OF CHANGE OF FLUX."

Further experiments show that the value of the induced E.M.F. is directly proportional to the rate oc change of flux.

The above statements of experimental fact are now given the status of a physical law, known as <u>Faraday's Law</u> which states:-

"Whenever the magnetic flux through a circuit changes, an E.M.F. is induced in the circuit: this E.M.F. is proportional to the rate of change of flux.

Lenz's Law.

So far as the direction of an induced E.M.F. is concerned, it has been observed that the reversal of any inductive operation results in the reversal of the induced E.M.F.

Lenz's law is a general statement from which the direction of an induced E.M.F. in any given case may be deduced and states that:-

"<u>Induced E.M.F.'s act in such a direction as to oppose the action to which they are due.</u>

Since the immediate cause of an induced E.M.F. is a change of flux, Lenz's law means that such E.M.F.'s will try to drive a current in such a direction in the circuit that the flux produced thereby will try to neutralise the impressed flux change.

AERIAL THEORY

1. In order to utilize the radio energy created by the transmitter pulse, the energy must be converted into radio waves which can be sent out to strike any object in their outgoing path. The aerial functions as a converter of radio energy into radio waves which can be radiated in any desired direction. If the waves strike an object they are reflected and the reflected waves are returned to the aerial, and converted back into radio energy and then fed to the receiver.

2. Half-Wave Dipole

The fundamental aerial from which most aerial arrays are built is the half wave ($\frac{1}{2}\lambda$) dipole. The dipole is made of copper tubing and is cut to half the wavelength used on the radar station. So if the radar station operated on a wavelength of 1.5 metres, the dipole would equal .75 metres (29.7 INS) in length. The dipole is mounted in the horizontal plane.

3. Properties of a Dipole

A single dipole in free space when examined in the "end-on" position will send out radiation in all directions and if the dipole is horizontal the vertical polor diagram will be a circle as in Fig. I. This does not mean to say that the radiation goes out as far as the ucred line and then stops but that the amplitude of the radiation along the rim of the circle is constant. Fig. I is then a Vertical Polor Diagram showing the relationship between amplitude of radiation and direction.

A single dipole will as we have already seen, send out radio energy in all directions around itself. The greatest amount of energy goes directly outwards at right angles to the length of the dipole, with decreasing amounts of energy towards the ends where the flow of energy is almost nil.

A target at right angles to the dipole will give a strong echo but one in line with the end of the dipole will offer a very weak echo (theorectiaally no echo). The horizontal radiation pattern of a dipole in free space is shown by the horizontal polor diagram in Fig. II.

In Fig. II AB represents the dipole viewed from a position directly above. The circles show the radiation pattern from the dipole AB. The lines OC, OD, OE, OF, represent the strength of the signal. (Note the decrease in signal strength as the end "B" of the dipole is reached.)

If we try to picture the radiation in three dimensions we find that the radiation goes out in all directions as shown in Fig. III.

4. Reflectors

Since operational aircraft can at the present fly to a height of approximately 60,000 ft. a great deal of energy is wasted as can be seen from a study of Fig IV.

In Fig. IV we have a station at "A" and it is desired to provide radar coverage in let us say an Easterly Direction. Using a single dipole, it will be seen that backward radiation will equal that of forward radiation. Since it is desired to "look" in front of the station (to seawards) the backward radiation is reduced or eliminated by the placing of another dipole a certain distance behind the radiating dipole.

This dipole is termed a "Reflector" and re-radiates the otherwise back-flowing radio energy thus throwing it forward in the desired direction. The result is a greater concentration of energy and range in front of the station. Fig. 5 shows the result of a reflector.

Reflectors can be tuned or untuned. The tuned reflector is used at CH stations. The length is of the order of .49 λ and is placed $\frac{1}{4}\lambda$ behind the radiating dipole.

On G.C.I. Stations a wire mesh reflector is used. The reflector covers the entire length and breadth of the aerial and is placed on odd length of a wavelength behind the dipoles.

C.H.E.L. stations or centimetre stations use parabolic reflectors.

Stacking (Vertical Radiation Pattern)

Referring to Fig. 4, it will be seen that a great deal of radio energy is being wasted above the 60,000 ft. level. To concentrate the surplus energy into an area where it is most required, the dipoles are placed or "stacked" vertically above one another. This produces a radiation pattern as shown in Fig. 6.

Baying (Horizontal Radiation Pattern)

To provide a narrow beam in the horizontal plane and thus to offer better bearing facilities, the dipoles are placed horizontally end to end as in Fig. 7. By increasing the number of bays the beam is made narrower, thus concentrating the radio energy at right angles to the length of the bayed dipoles. As a result of baying, small areas of radiation called side lobes are produced but these only affect readings at close range. See Fig. 8.

Lobes and Gaps

One of the basic factors in radar is that electro-magnetic waves are reflected by conducting objects in their path. The earth itself is as much a reflecting surface as a hill.

Formation of Lobes and Gaps

Were it possible to erect an aerial in free space which would be free from reflecting surfaces such as the earth itself, then the vertical coverage would be as shown in Fig. 9.

This however is not possible since it is not possible to remove the aerial for enough from the earth's influence.

One of the basic factors in radar is that radio waves are reflected by conducting objects in their path. The earth itself is as much a reflecting surface as a hill or aircraft.

The Direct and Indirect Path

The radio waves proceed from the aerial to an aircraft via two paths - the direct path - from the aerial to the aircraft, and the indirect path - from the aerial to the earth surface and by reflection to the aircraft as illustrated in Fig. 10.

Path Difference

It is at once obvious that the direct ray of radio waves does not travel as far as the indirect ray. The difference in length is known as the PATH DIFFERENCE and is measured in wavelengths.

Change of Phase in Reflection

When a series of troughs and crests strike the ground, each crest is reflected as a trough and each trough as a crest. See Fig. 11.

In other words, for horizontally polorised waves there is a 120 degree phase change on reflection.

A place change of 180 degree is equal to a path difference of $\frac{1}{2}$ a wavelength.

As a result of this path difference direct and indirect path radio waves ~~interact~~ on each other in space. At certain points in space the waves from the direct and indirect paths arrive in phase i.- two troughs or two crests combine to form a strong signal or area of radio energy.

Where two waves arrive out of phase "that is" where a trough and a crest meet earth waves cancel each other out thus giving rise to no signal or area of energy. The result is that areas of radio energy are built up in certain areas in space. In other areas there is no energy present.

An area of radio energy is termed a LOBE
An area of no radio energy is termed a GAP

This results in the vertical ~~coverage~~ of a station being broken up in lobes and gaps as shown in Fig. 12.

It may be said that when the path difference is an even number of $\frac{1}{2}$ wavelengths a gap is formed e.g. 2, 4, 6, 8, wavelengths; odd number of wavelength producing lobes.

The angles at which the lobes and gaps form, can be determined by the following formular:-

Angle of 1st Lobe

equals $\dfrac{47 \times \text{wavelength } (\lambda) \text{ in metres}}{\text{Height of aerials above the reflecting surface (in feet)}}$

or simply $\dfrac{47 \times \lambda}{h}$

Angle of 2nd Lobe

equals $\dfrac{3 \times 47 \times \lambda}{h}$

Angle of 3rd Lobe

equals $\dfrac{5 \times 47 \times \lambda}{h}$

Angle of 1st Gap

equals $\dfrac{94 \times \lambda}{h}$

Angle of 2nd Gap

euqals $\dfrac{2 \times 94 \times \lambda}{h}$

Angle of 3rd Gap

equals $\dfrac{3 \times 94 \times \lambda}{h}$

<u>Eg. 1</u>

<u>To find Angle of 1st Lobe given:-</u>

of station 10 metres and height of aerial array 200 ft.

1st Lobe equals $\frac{47 \times \lambda}{h}$ equals $\frac{47 \times \cancel{10}}{\underset{20}{\cancel{200}}}$ equals 2.35 degrees

<u>So angle of 1st Lobe equals 2.35 degrees</u>

<u>Eg. 2</u>

<u>To find angle of 1st Gap given:-</u>

equals 10 metres
h equals 200 ft.

1st gap equals $\frac{94 \times \lambda}{h}$ equals $\frac{94 \times \cancel{10}}{\underset{20}{\cancel{200}}}$ equals 4.7 degrees

<u>So angle of 1st gap equals 4.7 degrees</u> (See fig. 14)

It can be seen that by altering the height of the array, the angle of the lobes and gaps are altered. If it is desired to get low coverage the aerial must be placed as high as possible. The position of the lobes and gaps may be altered by altering the wavelength.

<u>The following points should be remembered:-</u>

(a) By <u>increasing</u> the effective height of the aerial, the angle of the lobes and gaps are <u>decreased</u>.

(b) By <u>decreasing</u> the effective height, the angle of the lobes and gaps are <u>increased</u>.

(c) By <u>increasing</u> the wavelength, the angle of the lobes and gaps are <u>increased</u>.

(d) By <u>decreasing</u> the wavelength, the angle of the lobes and gaps are <u>decreased</u>.

<u>Remember:-</u>

(a) The number of lobes depends on the wavelength and the height of the aerial.

(b) The shorter the λ and the higher the aerial the more lobes and the smaller the angle of

(c) Path difference of even numbers of $\frac{1}{2}$ wavelengths gives a gap
Path difference of odd numbers of $\frac{1}{2}$ wavelengths gives a lobe

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ELECTRO-STATIC C.R.T. (Height Range Tube.)

Introduction.

Referring to the precis entitled "Principles of Radar," the Cathode was simply described as an "electrical" stop-watch used at all radar stations to measure the interval of time taken by radio waves to return from a distant object to the source of their transmission, the time interval being subsequently converted into range. This precis attempts to describe in simple detail the two main types of C.R.T. used in Radar.

Definition of a C.R.T.

"A Cathode Ray Tube (C.R.T.) is a thermionic valve in which the electrons emmitted from the hot cathode are accelerated to a high velocity, focussed into a beam, and allowed to impinge upon a specially prepared translucent screen which flouresces or glows at the point where the beam makes contact."

The narrow beam of electrons may be deflected by electric or magnetic fields of force. Since the beam consists only of moving electrons under the guidance of suitable magnetic fields its weight and inertia are very small. It can consequently be made to follow, instantaneously, rapid variations in the deflecting field.

Function fo the C.R.T. (Electro-static.)

The function of the C.R.T. is to provide the operator with a visual display of the range of a distant object (aircraft), thus revealing one side of the "information" triangle, namely:-

Range,
Bearing or Azimuth and
Height,

three qualities which are essential to the establishing of the position of an aircraft relative to the radar station or to the ground immediately beneath the aircraft.

Although in the main, only two main types of C.R.T. are utilized, it is possible by suitable modification to provide all essestial information (height, bearing and range) by the use of two C.R.Tubes only. (See precis entitled "Types of Radar Displays" for fuller treatment.)

Components of C.R.T.

The following are the components of the electro-static C.R.T.

(a) The Cathode
(b) The Grid
(c) First Anode
(d) Second or Focus Anode
(e) Third or Final Anode
(f) "X" Plates
(g) "Y" Plates
(h) Graphite Coating
(i) Getter Plates
(j) Glass Envelope
(k) Flourescent Screen

The Cathode.

The Cathode is usually of the indirectly heated type and consists of a small nickel tube closed at one end. The emmissive substance usually Barium Oxide, is situated in a depression in the closed end of the tube (cathode) and the heater, supplied with an alternating voltage (from ± 4 to ± 6·3 volts, depending on the particular C.R.T.) is inserted through the open end of the tube. The beam (electron) current is of the order of 50 to 300 micro-amps. Directly heated filaments are not commonly used in cathodes except in soft tubes, since if they are supplied with an alternating voltage the electron stream is likely to be adversely affected. The voltage applied to the cathode is of the order of -4,000 volts.

The Anode.

The Anode is mounted a short distance from the cathode on the side nearer the flourescent screen, taking the form of a disc with a hole of about 1 m.m. in diameter in the centre.

The potential of the anode is maintained at some hundreds of thousands of volts positive relative to the cathode in order to accelerate the electrons. Some electrons travelling at high speed from the cathode are collected by the anode, whilst some pass through the hole and continue to travel down the tube until they strike the flourescent screen. This anode is at

(Earth Potential)

The Grid

Only a small proportion of the total number of emitted electrons pass through the hole in the first anode unless the electron stream from the cathode can be compressed into a narrow beam which can pass through the anode aperture. This compression is performed by the grid which usually takes the form of a hollow nickel cylinder surrounding the cathode.

If a potential, negative compared with that of the cathode, is applied to the grid a region of minimum potential is produced in the neighbourhood of the cathode. The immediate effect of this is to reduce the divergence of the electron stream. Increasing values of negative potential in the grid cause the electron stream to become more and more compact until at some optimum value the majority of the electrons pass through the anode aperture.

However, if the negative potential is increased beyond this value, there is an appreciable reduction in the beam current. The brightness or brilliance of the spot on the C.R.T. screen depends on the number of electrons reaching the screen in a given interval of time and so is controllable by the potential on the grid. The grid potential can be made sufficiently negative so that the grid filled neutralises that of the anode. This has the effect of cutting-off the beam of electrons thus "blacking out" the spot on the tube face.

This electrode is at - 4010 to - 4050 V.

Second Anode or Focus Anode

The electron beam emanating from the cathode is divergent, due in part to the mutual repulsion of the electrons and to the angle at which electrons from different parts of the cathode pass through the anode aperture. This divergence tends to cause the spot of light on the screen to be large and diffase. To make the spot small and well defined, the electrons must be made to converge so as to strike the screen over as small an area as possible. A focusing system is thus employed to produce the alive effect. In a sharp and well defined spot when focus is almost independent of the brightness control. Hence a three anode focusing system is used. The focus anode in conjunction with the 1st and 3rd anodes set up "magnetic fields" of different intensities which determines the focul point of the beam just as the shape and thickness of a lense determines the focul point of a beam of light.

The voltage of the anode equals - 3010 V (variable).

Third and Final Anode

The 3rd anode is identical in construction with the 1st anode. Its function is to give added acceleration to the electrons on their way to the tube face and to aid the second anode. By its higher potential in electricity suitable focusing Its electrode is at Earth Potential (O.V.) to avoid strong fields, and to build up between deflector plates and final anode.

"X" Plots

It is necessary that the electron beam should be deflected after it leaves the vinal anode. In its simplest form the deflection system is such that the beam of electrons can be deflected to and fro in a direction at right angles to that of the beam.

Electric Deflication (Horizontal)

An electron situated in a uniform electric field experiences a force in the direction of the field. Consequently a beam of electrons passing through an electric field will be deflicted. This defliction is usually obtained by applying a potential difference to a pain of

parallel plates so situated within the tube that the beam passes between them shortly after it emerges from the focusing field (see Fig. 2). The beam experiences a force proportional to the field strength and therefore to the potential between the plates. This has the effect of bending it towards the more positive of the two plates. If the potential difference between the deflictor plates is constant, the beam is permantly deflicted. If an alternating potential difference is applied to the plates, the spot is swept too and fro across the tube and, if the frequency is sufficiently great, persistence of vision will cause it to appear on the screen as a bright line of light commonly referred to as the "trace" or "time-base". (Y and X plates seem disconnected this way).

"Y" Plates

It is possible to obtain vertical defliction of the beam and consequently the spot by mounting two mutually perpendicular plates in the neck of the glass envelope (See Fig. 2). This set of plates is termed the "Y" plates to indicate the direction of the deflections relative to the structure of the tube. The "Y" plates are mounted between the "X" plates and the 3rd anode. Allowing for the delfection of the beam, the plates are not usually parallel throughout their whole length but usually diverge towards the screen. The width of the "X" plates is larger than that of the "Y" plates to allow for the deflection of the beam the 1st pair ("Y" plates) suitable potentials applied to the plates allow the beam to delfect vertically.

Deflection Sensitivity

The deflection sensitivity of a C.R.T. employing electric deflection is given by the deflection of the spot in millimetres for a potential difference of one volt between the two deflector plates. This deflection is found to be inversly proportional to the potential difference between the cathode and final anode, on the assumption that the mean potential of the deflector plates is the same as that of the final or 3rd anode and also inversly proportional to the square of the velocity of the electrons.

For a given value of the potential difference between the 3rd anode and the cathode, the closer the plates, or the longer their length, or the larger the tube from the plates to the screen the greater is the deflection sensitivity. The use of a long tube however, introduces difficulties in producing a good focus. The focusing system has no control over the electron beam once it has left the focusing field and, due to mutual repulsion of the electrons, the more remote the screen the less sharp will be the focus.

Fluorescent Screen

The screen consists of a translucent layer of fine powder adhering to the end of the tube. The emission of light during the actual stimulus of the beam is termed "fluorescence"; the light which continues to be emitted after the stimulus has been removed is due to phosphorescence and is called "after-glow". The material of the powder determines the colour of the trace, and also the duration of "after glow".

The following instances produce the appropriate colour tint:-

Calcium tingstate	- blue violet trace
Zinc silicate	- green trace
Zinc sulphate	- red trace

Graphite Coating

N.B. Graphite coating is a physical carbon compound.

The electrons having bombarded the screen face are conducted to earth via the graphite coating which is a chemical compound (carbon) extending the screen face to the 3rd or final anode. It may be recognised by its black colour. The "drawing off" as it were of the

"spent" electrons facilitate a building-up of "spent" electrons which if left near the screen face would by their negative nature repel the on-coming electrons bean, thus causing lack of definition on the tube face or at worst, the disappearance of the "spot".

Glass Envelope

The glass envelope contains the electrodes. It is sealed off after the air pressure has been reduced to about 10 - 6 n.n. if necessary.

Giter Plates

To extract the lost traces of oxygen from the tube, three "giter" plates are installed on the supporting struts of the electrodes. The plates contain a chemical which is electrically fired after the tube has been sealed off. This has the effect of producing an almost complete vacuum. It is of interest to note that the end of a tube of diameter 12" (inches) carries a load of 314 tons due to atmospheric pressure.

Operational Aspect of C.R.T. (H/R)

Filament	Heats the cathode
Cathode	The cathode which is indirectly heated and cooled with Barium Oxide to give greater emersion of electrons at low temperatures, emits electrons when heated.
Grid	The grid controls the flow of electrons by application of varying negative potentials.
First Anode	Attracts the electrons from the cathode.
Second or Focus Anode	Creates electro-static lense with 1st and 3rd anodes, which focusses, the electrons beam at the tube face.
Third Anode	Attracts and accelerates the electron stream.
"Y" Plates	Produces ground ray echoes and calibrater pips.
"X" Plates	Produces time base or trace.
Fluorescent Screen	Glows when bombarded by electrons thus giving time to trace echoes etc., to record coating is provided to give an "afterglow".
Graphite Coating	Collects the "spent" electrons which have bombarded the screen returning them to earth via the 3rd anode.
Glass Envelope	Contains all the electrodes in as near a vacuum as it is practicable to achieve.
Gitter Plates	Holds a chemical which when electrically fired burns and consumes residual cases remaining after initial evacuation of Glass Envelope.
Controls	See Precis entitled "Radar Displays".

ELECTRO-MAGNETIC C.R.T. (P.P.I. Tube)

Introduction.

In the precis entitled Electro-Static C.R.T. (Height range tube), reference was made to the two main indicating units used at all radar stations. This precis attempts to describe the Electro-Magnetic C.R.T.

Function of Electro-Magnetic C.R.T. (P.P.I.)

The function of the Electro-Magnetic C.R.T. or P.P.I. is to present a plan position of an aircraft to the operator. (See "Radar Display" precis.)

Components of Electro-Magnetic Tube.

The components of the Electro-Magnetic Tube are:-

(1) Cathode
(2) Grid
(3) First Anode (Some displays lack a first anode.)
(4) Graphite coating
(5) Focus coil
(6) Fixed deflector coils
(7) Flourescent screen
(8) Glass Envelope

The cathode, grid and first anode (if present) and glass envelope, are similar to their corresponding elements in the electro-static C.R.T. The cathode is at earth potential.

Graphite Coating.

In the place of first and final anodes the graphite coating, of a carbon compound or "Aquadag", is used to attract and accelerate the electrons in the direction of the tube face. It also performs the function of conducting the spent electrons away from the screen face. The voltage applied to the graphite is of the order of +4000 volts.

Focus Coil.

The focussing coil with its iron core and small gap, is mounted on the neck of the tube. The coil is wound on an annular ring in which is cut a grove; an air gap is provided in order that the magnetic path may pass through the tube. The fields at the opposite points of the diameter are in the same direction and therefore, oppose. As a result the lines of force between the poles lie parallel with the axis as shown in Fig.2. By passing a current through the coil, suitable magnetic fields are set up. The effect of the magnetic fields is to cause a spiral motion of the electron stream which results in a focal point developing at the screen face.

Fixed Deflector Coils.

To describe in detail the operational aspects of the Fixed Coil System is beyond the scope of this precis. Suffice it to say that the deflector systems are situated close to the neck of the tube screen. These deflector systems are fed by a magslip which supplies current in a triangle of forces fashion. The resultant current force confines the trace between the centre and extremity of the tube and also causes it to rotate in synchronism with the aerial. The full treatment of Fixed Coil Systems is available in the precis entitled "Fixed Coil Displays."

Operational Aspects of Electro-Magnetic C.R.T. (P.P.I.)

The Cathode.

The cathode which is indirectly heated and coated with Barium Oxide, emits electrons.

The Graphite Coating.

The graphite coating is used in place of the anodes and attracts and accelerates the electron beam in the direction of the tube face. It also returns the "spent" electrons. In some tubes a first anode is installed, this performs the same function as the first anode in the Height Range Tube.

The Grid.

It controls the flow of electrons by varying the negative potential applied.

Focus Coil.
The focus coil focusses the beam, thus giving fine definition of the spot.

Fixed Deflector Coils.
As the name implies, these coils deflect the trace from the centre of the tube to the circumference, as well as causing it (the trace) to revolve in sympathy with the rotating aerial.

Flourescent Screen.
The flourescent screen glows under the bombardment of the electrons. The second coating on the screen provides an afterglow.

Controls.
For C.R.T. Controls see precis entitled "Radar Displays."

TABLE of differences between Electro-Static and Electro-Magnetic C.R.T!s.

Subject	Electro-Static	Electro-Magnetic	Remarks.
Brilliance	Grid	Grid	Negative with respect to the Cathode.
Focus	2nd Anode	Focus Coil	Electro-stacic as lens Electro-magnetic by spiraling
Signal Input	"Y" plates	Grid as pos. voltage	Electro-static - spot deflection Electro-magnetic Intensity Modulation.
Time Base	"X" plates	Time base coils (Fixed.)	Voltage waveforms into current waveforms
Shift	"X" & "Y"plates.	Deflector coils (Fixed)	
Calibaration Input	"Y" plates	Grid as pos. voltage	
Voltage	Cathode = -4,500v Final anode = earth potential	Cathode = earth potential Graphite = +4,500v.	
Use	Height Range Console	P.P.I. Console.	

RESTRICTED

NOTES FOR RADAR OPERATORS.

RADAR Radio Aids to Detection and Ranging.

Brief history of Radar

It started in 1933, by Appleton & Watson-Watt, who were trying to measure the distance of the IONOSPHERE, which is a layer about 60-80 miles from the earths surface. These two discovered that you could detect long range objects such as aircraft. In 1937 at BAWDSEY, they set up the first Radar station. After 1937, as range finding gear improved, stations known as C.H. were set up in S.E. England. Similar stations were set up all over Britain in 1939 and we had our first Radar coverage.

Elements of a Radar Station.

(1) Powerful Transmitter
(2) Sensitive Receiver
(3) Power Supply
(4) Display Unit
(5) Aerial System
(6) Spark Gap

P.R.F. & T.R.F.

Pulse Recurrence Frequencies, are pulses which go across from A - 0 miles to B-200 miles, at a rate of 400 times per second to coincide with the transmitted pulse which is radiated into space also at 400 times per second. This trace recurrence frequency is too great for the human eye to see, other than as a straight horizontal green line. One trace means one spot travelling from A - B, in the time of 1/400 of a second. Where an aircraft is in the 100 miles range the pulse has to travel 100 miles out and 100 miles back, the total being 200 miles which in time taken 1/931.2 secs. An echo due to the returning pulse, will appear on the trace at an instant determined by the time of travel (i.e. 1/931.2 secs). Above the trace we fix a scale, which is marked out in miles, we could mark the scales as intervals of time but as we are interested solely in the range of aircraft we disperse with time scales. For example, where an aircraft has a range of 100 miles we could also mark the range scale as 1/930.2 sec.

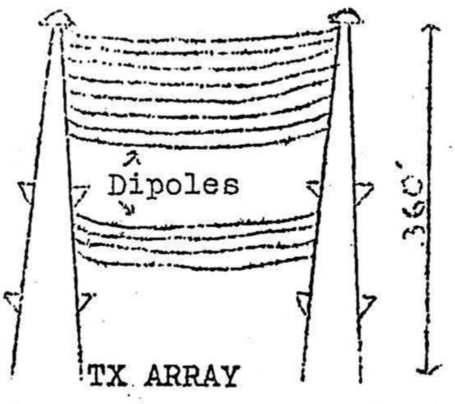
TYPES OF GEAR

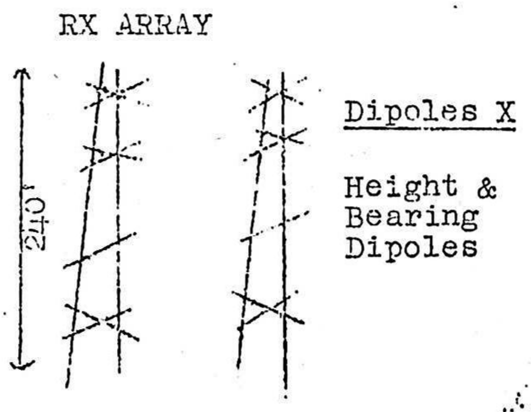
Chain Home (C.H.)

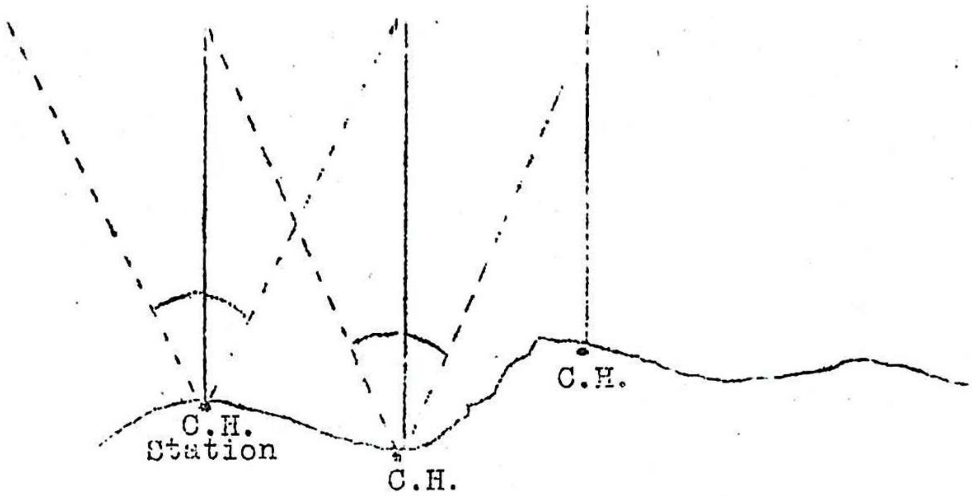
Has a TX array on a 360 ft. steel tower and the RX on a 240 ft. wooden tower. C.H. stations are used to plot high and medium flying aircraft from 5000 ft. - 45,000 ft. Placed about 80 miles apart, C.H. has a range of 200 miles, and floodlights an area of 120° coverage on horizontal plane.

A line drawn through the centre of coverage, is known as the line of shoot. It will be seen that the siting of C.H. Stations ensures no gap in the horizontal coverage.

Below 5,000 ft. C.H. is of no use and therefore other Radar gear was brought into use in 1940.

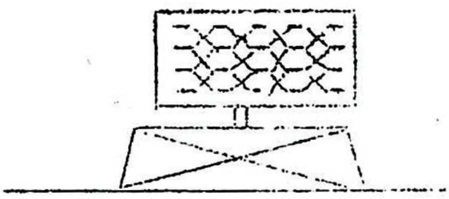






Chain Home Low (C.H.L.)

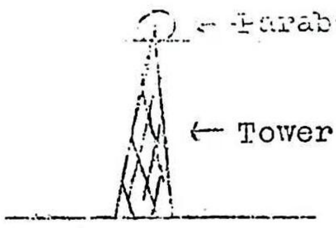
Was introduced in 1940 to plot Medium and Low flying aircraft. The array is mounted on a gantry 25 ft. from the ground. The aerial consists of 40 Dipoles. Behind the framework is an ordinary wire mesh used as a reflector. The Aerial rotates round the full 360° and gives a beam of 16° - 18° and the range is still 200 miles. Early C.H.L. had separate aerials for Tx and Rx, but now there is one aerial for both which rotates through 360°.



5 Bay - 4 stack
Aerial Array

Chain Home Extra Low (C.H.E.L)

This gear was introduced in 1942. It was also known as C.M. (Centemetric Equipment) and C.D. (Coastal Defence Equipment), used for low flying aircraft and shipping. It has a range of 220,000 yards or 120 miles, and a beamwidth of 1 - 5°. The radiated energy passes up the waveguide and is reflected forward in a narrow beam by the paraboloid.

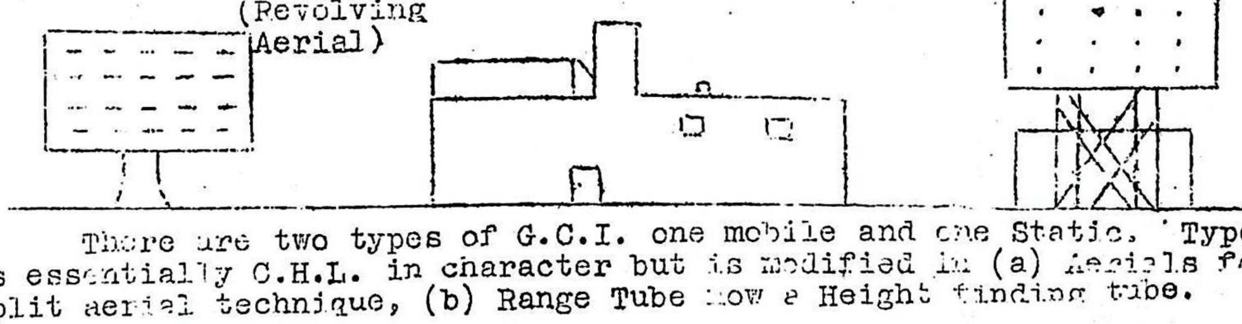


Light Warning (L.W).

Has the rotating beam technique with a beamwidth of 4° and a range of 60 miles. L.W. is a highly mobile unit, used in co-operation with Army Liaison Units.

G.C.I.

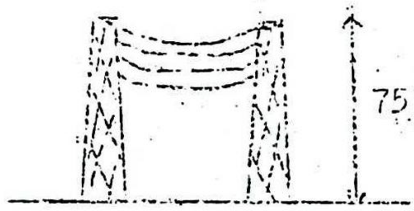
Ground Controlled Interception has a beamwidth of 15° using reflecting beam technique with a range of 60-90 miles, used as a controlling station to direct intercepting fighters to their targets. This gear is equipped with Height finding equipment. It has 4 bay, 4 stack.



There are two types of G.C.I. one mobile and one Static. Type 15 is essentially C.H.L. in character but is modified in (a) Aerials for split aerial technique, (b) Range Tube now a Height finding tube.

Mobile Radar Unit (M.R.U).

This was brought out after C.H. and initially used to fill the gap of our coverage until heavy radar gear can be brought into play. It was used a lot in France and was first mobile type, taking about two days to erect. The two towers were 75 ft. and collapsible for easy transport. Aerials same as C.H. wavelength shorter than C.H. and heights can be found though limited. Angle of elevation was still quite high compared with C.H.L.



GEOGRAPHICAL REFERENCE SYSTEM (GEOREF)

1. Throughout the last war a system of positional reference known as the BRITISH MODIFIED GRID was generally used. B.M.G. was however as its name indicates purely local in its application. Consequently as operations spread further afield a grid with a world-wide coverage was sought.

In answer to this problem, on the 31st August 1950, a new system of positional plotting and map reference was adopted by the Royal Air Force. The grid, which was named the Geographical Reference System - in short GEOREF - fulfilled all requirements and has remained in use until the present day.

One of the problems arising from B.M.G. was the complicated mass of lines which resulted when it was applied to a map which already bore both latitude and longitude. GEOREF, however, is based on latitude and longitude, thus superimposing it on almost any map is infinitely easier, than it is to do with the more conventional Military Grids.

2. Latitude starts at the Equator and works both North and South through 90 degrees - a total, therefore, of 180 degrees of Latitude. GEOREF, however, starts at the South pole and working North divides the 180 degrees of Latitude into twelve bands of 15 degrees each - these bands, starting once again at the South Pole, are lettered from A - M inclusive omitting I and O.

3. Longitude, starting at the Greenwich Meridian, is continued both East and West to the 180th Meridian - thus giving 360 degrees of Longitude in all. GEOREF starts at the 180th Meridian and, Eastwards, divides the World into twenty-four 15 degree bands lettered A - Z omitting I and O.

4. It will now be realised that by this system the World's surface has been divided into 288 quadrangles each of 15 degrees, any one of which may be indicated by quoting two letters. These fifteen degree quadrangles are known as Primary Squares, the method of indication is to give the Easting i.e. the letter designating the band of Longitude, followed by the Northing - the letter designating the band of Latitude.

The primary squares are divided, both in Longitude and Latitude, into I degree bands - thus giving 15 x 15 1 degree quadrangles in each Primary Square. Starting at the Western Meridian of the Primary Square the degree units are lettered A - Q inclusive, omitting I and O. Similarly they are lettered A - Q from the Southern Parallel of the Primary Square; it is now possible to indicate any one degree quadrangle within the Primary Square by giving two letters, once again the first designating the Northing and the second the Easting. Furthermore it is possible, by quoting four letters - two of the Primary Square followed by two of the Secondary Square - to designate any one degree quadrangle on the Earth's surface e.g. MTLG.

5. By further systematic expansion, the Secondary Squares are divided into minutes 60 x 60. It is important to note that in GEOREF the minutes are always read from East to West and South to North; regardless of the part of the World in which point indicated may be situated a typical four figure reference then, will read MKLG 5402. In normal operations where risk of ambiguity with neighbouring Primary Squares does not arise the first two letters may be dropped and the reference becomes LG 5402 the position thus given is accurate to one square nautical mile - 1 minute of Latitude equals 1 nautical mile.

N.B. Due to the curvature of the Earth's surface, it is only at the Equator that 1 minute of Longitude equals 1 nautical mile - its size obviously decreases until the meridians converge at the Poles. In the parallel of Latitude in which England lies ten minutes of Longitude equal approximately six nautical miles.

6. As the degrees were divided into minutes, so it is possible to divide the minutes, themselves, into seconds. By this means a reference to an accuracy of 1 second of Latitude and Longitude, i.e. approximately 100 feet, may be given. Of the eight numerals which must necessarily be given in a reference of this nature the first four represent the minutes and seconds of Longitude by which the designated point lies Eastwards of the Western Meridian of the Secondary Square; the latter four, the minutes and seconds of Northing from the Southern parallel of that Square. A reference would now read MKLG 54320242. An accuracy of 100 feet will, however, be rarely required and it is unlikely that eight numeral will ever be met with in practice.

7. The important points to remember are that GEOREF originates at the 180th Meridian at the South Pole and is always passed Easting first and Northing second.

8. <u>GEOREF AS DISPLAYED IN THE OPERATIONS ROOM</u>

GEOREF on the General Situation Map, Fighter Table and P.P.I. Tube does not show the Primary Squares, thus all plotting and telling is done in two letter, four numeral references.

In order to further simplify the grid it has been found convenient to divide the Secondary Squares into Tertiary Squares of ten minutes of Longitude and Latitude. Thus it will be seen that in a normal two letter four numeral reference the second and fourth numerals are estimated by the Plotters and Tellers i.e. in the reference MF 5342, the 5 and 4 are actually marked on the Table whereas the 3 and 2 are estimated. This practice was also used with BRITISH MODIFIED GRID.

On the G.S.M., the object of which is to give a general air picture, a certain amount of accuracy is sacrificed in order to gain more speed. On this Table, therefore, two figure plotting is done - only the Tertiary Square being given. A reference which, on the Fighter Table appears as PF 5403, is given as PF 50 (Peter Fox Five Zero) on the G.S.M. All letters are passed in the phonetic alphabet.

Comparison of Major Types of Equipment

	C.H.	C.H.L.	C.H.E.L.	L.W.	G.C.I.
Coverage	Floodlit	Beamed	Beamed	Beamed	Beamed
Range	200 miles	200 miles	120 miles	200 miles	60-90 miles
Horizontal Beamwidth	120°	15-18°	1°-5°	4°	15-18°
PRF & TRF	25/sec	400/sec	500/sec	400/sec	400/sec
Wavelength	10-14mtrs	1·5mtrs	10 cms	1.4 mtrs	1·43 mtrs
Frequency	25 mc/s	200 mc/s	3000mc/s	214 mc/s	209mc/s
Intermediate Frequency	2 mc/s	45 mc/s	60 mc/s	30 mc/s	45 mc/s
Bandwidth	50,200/ 500 kc/s	4 mc/s	5 mc/s	2-2.5mc/s	4 mc/s
Pulsewidth	16 mic/s	3,5,8,mic/s	1·6 mic/s	2 mic/s	2 mic/s
Bearing	X dipoles	Rot.Beam	Rot.Beam	Rot.Beam	Rot.Beam
Aerials	Separate TxRx	Combined Tx Rx	Combined Tx Rx	Combined Tx Rx	Combined Tx Rx
Reflectors	Tuned	Untuned	Untuned	Untuned	Untuned
Type of Site	Flat or Sloping to Sea.	High Cliff	High Cliff	Flat ½ mile radius	Saucer shaped depression

Kc/s - Kilocycles (1,ooo cycles) mc/s - Megacycles (1,000,000 cycles)
Mic/s - Micro-sec.(1,000,000 sec) 1 micro sec - 1/1,000,000th seconds.

C.O. - Chain Overseas. C.O.L. - Chain Overseas Low. Note - C.O.L. Majority of these were mobile compared with the static C.H.L. at home.

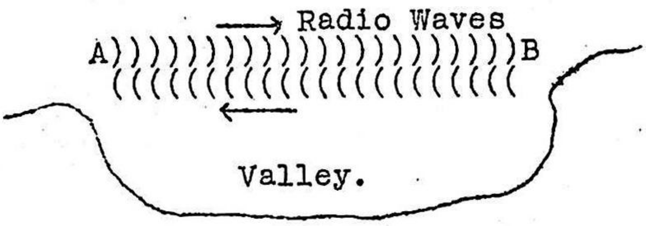
Range Assessment

Velocity of Radio Waves - 186,240 miles per second.
Therefore to travel 1 mile time taken is $\frac{1}{186,240 \text{ sec}}$

" " " 10 " " " " $\frac{1}{18,624 \text{ sec.}}$

" " " 200 " " " " $\frac{1}{931 \cdot 2 \text{ secs}}$

1,100 ft. per sec. Note - Speed of Sound



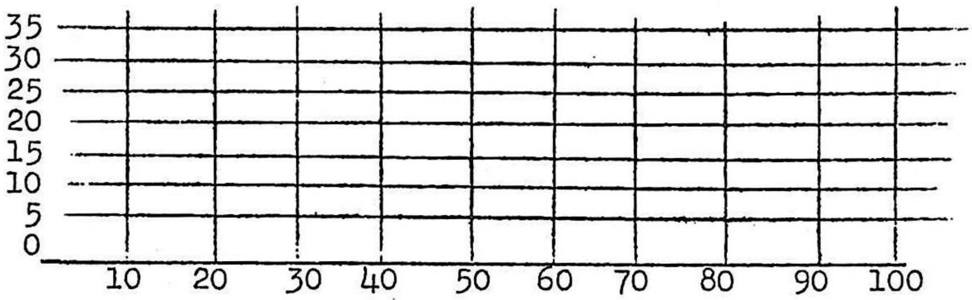
The speed of sound at sea level is 1,100 ft. per sec.

C.H. is known as Radar No.1, C.H.L. is known as Radar No.2.

ANGLES OF ELEVATION

These angles of elevation of the Stations are only approximate because we have to take into consideration the Wavelength of the Radar, and the particular site of the Aerial above the reflecting surface.

Height in feet



PLAN POSITION INDICATOR (P.P.I).

A Radial Time Base is produced from the centre of the screen and projected to the radius of the screen. Mechanical and electrical devices make the timebase move round the screen in a clockwise direction with the pivot in the centre. The PPI trace can indicate ranges from 0 - 60 - 120 miles on the PPI. The echo is shewn as a small crescent of blue light.

BEARING ASSESSMENT

We start the row of bearings by projecting a line from the centre of the tube to a position indicating True North. Project a line True South, then East and West, always calling True North 0° and reading through 360° in a clockwise direction.

The Radial Time base revolves at a speed of 4 - 6 revolutions per minute. The crescent is built up by successive traces producing little blips of light forming a crescent. Correct bearing is through the centre of crescent. The PPI was introduced at the end of 1941.

BRIEF OUTLINE OF ELEMENTARY ATOMIC STRUCTURE AND THEORY

All matter is composed of three things (1) Elements
(2) Compounds (3) Mixture

An Element:- Is the basis of all pure substances, such as Gold, Copper, Hydrogen, Helium. It is a pure substance and cannot be split up into any other substance e.g. the elements, Hydrogen and Oxygen when split up will each yield nothing except small particles of Hydrogen and Oxygen.

A Compound:- Is a chemical combination of two or more elements forming a substance possessing physical and chemical characteristics which may differ entirely from those of the original separate elements. e.g. Water is a compound of oxygen and hydrogen. Sodium Chloride is a compound made up of Sodium and Chloride.

A Mixture:- Is a physical combination of either elements or compounds. Each substance in the mixture can be isolated by physical means, and the mixture has no characteristics additional to those of the substances of which the mixture is composed, e.g. iron filings and Sulpher.

An Atom:- Is the smallest particle of an element which is indivisable. Atoms of any element seldom exist in an isolated condition, but combine together in groups of two or more to form molecules. On this basis the ultimate indivisable parts of a compound is otherwise a molecule or combination of Atoms, and the diameter is approximately $1{\cdot}6 \times 10^{-18}$ cm.

A Molecule:- Is the smallest part of a substance which can take part in a chemical combination or reaction, e.g. water is a molecule (and a compound). An Atom when split up consists of two things Protons and Electrons. These Electrons and Protons are the basis of all matter.

Ionisation:- Is occurring constantly in all matter and is caused by the temporary movement of Electrons from their outer orbits. We have two types of orbits (1) Inner. (2) Outer., and it is these two coming together which causes Ionisation. It is the outer orbital Electron in which we are interested but we call them free Electrons. There in a substance are of very little use by forming what is known as an Electric Current i.e. the passage of free Electrons through a conductor in a required direction.

The Conductor:- Is a substance with many free Electrons and will allow easy flow of their Electrons, e.g. Copper, Water and Nickel are good conductors.

Insulators:- An Insulator is a substance with few free Electrons and thus the substance offers considerable resistance to the easy flow of free Electrons.

Resistance:- No substance is a perfect conductor or insulator. The natural opposition offered to the flow of Electrons is termed Resistance therefore a good Insulator will have a high resistance, and this depends upon (1) Length (2) Cross sectional area, and the substance of which it is composed. e.g. Rubber and porcelain are good Insulators. To produce a flow of Electrons in a given direction in a conductor it is necessary to artificially create a pressure which will force the electron along. To do this we have to ensure an Electron deficiency at one end of the wire and an Electron excess at the other end. This difference in electrical charges is termed as Potential Difference and the force which creates the P.D. is called Electro Motice Force (EMF) EMF is electrical pressure which is measured in volts. It measures the amount of pressure made by the battery. Note. Battery does not produce Electrons or Electricity it just produces force which causes Electricity to flow.

Ampere:- Is the measurement of current flow measuring the number of Electrons in a conductor e.g. very difficult because of their small size so we have to take a certain quantity of Electrons and give that so many a name - Coulomb.

A Coulomb:- Is the quantity of Electrons which passes a given point in 1 second (i.e. $6{\cdot}3 \times 10^{19th}$) If one coulomb of Electrons passes a given point in 1 second, we say that we have a current of 1 Ampere flowing in the Conductor. Ten coulombs passing a point in 1 second - 10 amps current flow. Resistance is O H M S is measured.

O H M S Law States:- A current flowing in a conductor is proportional to the applied EMF and is directly proportional to the Resistance offered by that circuit providing the Temperature remains constant.

(EMF) Volts - V
(Resist) OHMS - R
(Amps) Current- I

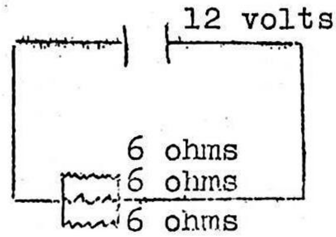
$$\frac{V}{IR}$$

These formulas always relate to D.C. Circuits. Knowing any two values of a circuit the third can be found.

(1) V- I x R (2) I - $\frac{V}{R}$ (3) R - $\frac{V}{I}$

When we have two Resistances in a battery we term them as Series. When you have Resistances in series you ADD them up to give a total Resistance.

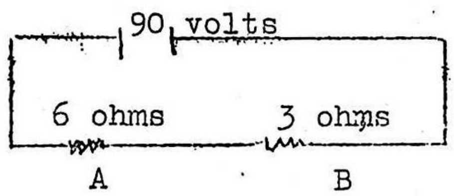
With the Resistance in Parallel you put the total under $\frac{I}{R}$ - all resistances added together $\frac{I}{R} = \frac{I}{r_1}$ plus $\frac{I}{r_2}$ plus $\frac{I}{r_3} = \frac{I}{R} = \frac{1}{6}$ plus $\frac{I}{6}$ plus $\frac{I}{6} = \frac{3}{6} =$ 2 ohms.



$I = \frac{V}{R} = \frac{12}{2} = 6$ amps.

Volts Drop across any Resistance in circuit is found by multiplying the Total I (main circuit current) times value of the particular Resistance.

e.g.



First find current $= \frac{V}{r + R} = \frac{90}{9} = 10$ amps

A = 1 x R
= 1 x A
= 10 x 6
= 60 volts

Volts Drop across A=60 v.
" " " B=30 v.
Total V = A + B = 90 v.

Find Volts Drop across
B = I x R
= I x B
= 10 x 3
= 30 volts

Total Volts droppage in the various resistances should equal the source of EMF i.e. the pressure supplied by the battery.

To find the Volts droppage in a sub-current as shewn below.

$\frac{I}{R} = \frac{1}{3}$ plus $\frac{I}{6}$ plus $\frac{I}{2} = 1$ ohm. Total R = 5 plus 1 = 6 ohms.

$I = \frac{V}{R} = \frac{24}{6} = 4$ amps. Sub C Droppage $= \frac{V}{R} = \frac{4}{3}$ plus $\frac{4}{6}$ plus $\frac{4}{2} = \frac{24}{6}$

= 4 amps.

Therefore Sub Current $\frac{V}{r_1}$ plus $\frac{V}{r_2}$ plus $\frac{V}{r_3} = I$

Watt:- A Watt is a unit of power and is the result of Volts x Amps.

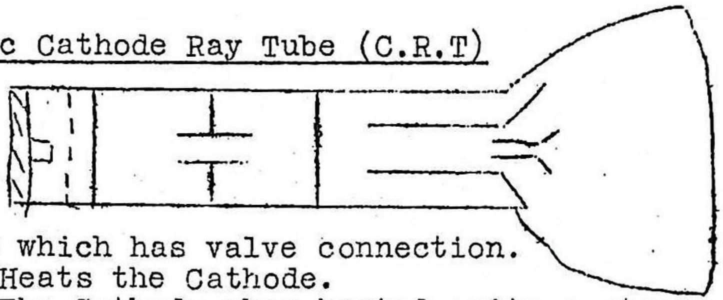
Magnetism:- Surrounding any magnet there is a magnetic field. The lines of force flowing from a magnet, flow from North to South. These lines of force never cross. Like poles repel unlike poles attract. The enlinement of Atoms set up a magnetic field. Internally lines flow from South to North, externally from North to South.

Solenoid:- If current is passed through a coil of wire a magnetic field is set up, similar to that of a magnet.

Formula for finding Watts.

$$W = V \times I \text{ or } I^2 E \text{ or } E^2 I$$

Electrostatic Cathode Ray Tube (C.R.T)



1) Base Plug which has valve connection.
2) Heater. Heats the Cathode.
3) Cathode. The Cathode when heated emits a stream of Electrons, and is coated with Barium Oxide to aid Electron emission.
4) Grid. The Grid controls the flow of Electrons by varying the P.D.
5) 1st Anode. Attracts the Electrons from the Cathode.
6) 2nd Anode. Focuses the Electrons into a narrow stream or beam.
7) 3rd Anode. Gives final velocity to the Electrons.
8) "Y" Plates. Gives Beam vertical deflection (Vertical shift)
9) "X" Plates. Gives horizontal deflection (Horizontal shift)
10) Fluorescent Screen. Glows when bombarded by electrons.
11) Graphite Lining. Conducts the electrons to earth after Spray bombardment, by way of the third Anode.
12) Permibility. (Soft Iron) The ease with which a material is magnetised
13) Retentivity. (Steel). The ability of a material to retain its magnetism after removal of the charge.

INDUCTION

Faradays Law. States when a conductor is placed in a magnetic field an E.M.F. is induced that is directly proportional to the rate of change of flux.

If we close the switch on aerial 'H', current will flow through a coil which will set up a magnetic field. This will start at 0° and grow outwards. In doing so, it will cut coil 'B' inducing an EMF that is directly proportional to the rate at which the flux cuts the coil at 'B'. No EMF is induced unless there is a change of flux.

Generation of A.C.

If you place a loop of wire between the pole pieces of a magnet and revolve the wire, an EMF will be induced in that wire that is proportional to the rate of change of flux.

Between points 'A' and 'B', the build up will increase to maximum, due to the fact that at point 'A' the number of lines cut is zero, while at 'B' the number is maximum. The process is repeated in the opposite direction (a decline instead of a build-up), thus in the remainder of the cycle the reverse takes place. A.C. - a conductor moving in a magnetic field and an EMF is induced due to Faradays Law.

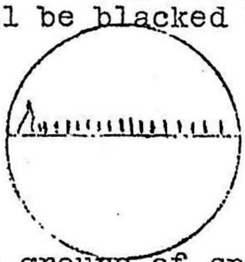
INTERFERENCE

The enemy send out pulse transmission (at the same frequency) on a similar PRF but instead of sending out one pulse per 400th sec. they send out multiple, and they appear on C.R.T. as many signals at constant range and constant amplitude (can be varied on both). A series of false echoes equal distances apart and all A.F. at the same bearing - no recognisable signal.

Unlocked Pulses

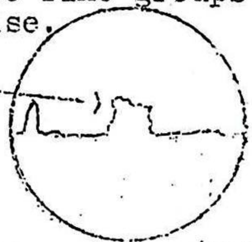
Caused by pulse T.X. but no attempt is made to lock to our T.X. or R.X. appearance. Responses varying in no amplitude and drifting across trace speed of drift with air is 30. Window ½ wavelength long, strips of metalised paper dropped from the enemy aircraft (strips drop at the rate of 300 ft. per minute). Window is the code name of interference by these strips.

The strips when struck by radar transmission of EMW reradiate a signal which is received by R.X., and shewn on the C.R.T. as a signal deflection (R.T) and increase in light blip on the P.P.I. in no way different to an aircraft signal. C.H. stations with their longwave lengths are not so subject to window jamming as with CHL and CHEL. Appearance on K.T. is that of small mass raid increasing in size whilst on P.P.I. large sizes will be blacked out. (lit up by malty crescents).

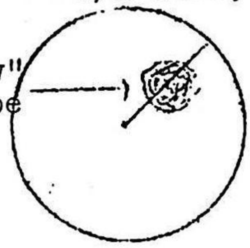


Car Ignition:- Appearance fine groups of spikes on H/R Tube, sound on X14 on CHL clicking noise.

"Window"
H/R Tube.

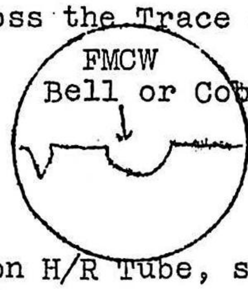


"Window"
PPI Tube



Frequency Modulated Continuous Wave (F.R.C.W)

Appearance:- A bell shaped echo drifting across the Trace on H/R tube, Sound on CHL wailing like a ship's siren.



R/T:- Appearance, echoes of varying amplitude on H/R Tube, sound X14 on CHL, speech is heard.

Jamming Cures.

1. Anti Clutter Gain Control for use on a C.H.E.L. Station. A device to enable control the amount of Gain on parts of the trade. The wave clutter is rather difficult to work through up to about 20 miles. So this control decreases the Gain amplification progress, i.e. from nil gain at zero to ·8 of normal gain at about 20 miles.

2. Intermediate Rejector Unit, (I.F.R.U)

Used on C.H. and C.H.L. This is a form of wave trap which in effect cuts out a portion of the Bandwidth. The amount of rejection can be varied between ·5 and 3·5 mc/s. Two main controls are used. (a) There is amount of rejector (b) Determines which part of the Bandwidth to be rejected.

I.F.R.U. cures Con Wave, if on a fixed Frequency I.F.R.U. deals with one small band of frequencies at one time. Therefore varying C.W. or F.M.C.W. cannot be cut out altogether, i.e. the bell of F.M.C.W. only partly cut out or nicked.

3. Anti Jamming Black Out Unit (A.J.B.O)

Used on C.H., used from F.M.C.W. jamming (Bells). This blacks out the annoying Bell shapes and just leaves the gaps in the trace where the bells were. The only sign of jamming will be a gap in the Base line (trace) sliding to and fro it is then possible to carry out a reduced amount of plotting.

4. Intentional Jitter Anti Jamming (I.J.A.J)

Used on C.H. This device is provided to unlock locked pulses, so that they would jitter along the Time Base, thus real echoes of reasonable strength can be seen and picked out more easily, especially with the additional use of Filters.

A.J. C.R.T. and filters for C.H. only. The Anti-Jamming Tube is a CRT range Tube, with long after glow. Electron bombardment gives an instantaneous blue trace on the screen, but the after glow left on the screen after the Electron beam has moved away is YELLOW. With the use of blue filter glass (not issued now) we see only the instantaneous trace, while if we look through Yellow Filter we see only the after glow. An echo will produce a definite kink in the trace and will be seen through Yellow Filter while Interference normally seen is cut out. The use of filters slows down Gonio D/F. Green Filter is used to pass a little after glow through, while modified Yellow Filter allows a little instantaneous trace through.

6. Narrowing Bandwidth C.H. and C.H.L. reduces the width of the Bell shaped F.M.C.W. Very often the A.J.B.6. is used in conjunction with narrowing the band width of the Station.

I.F.F.

In order to distinguish between Friendly and Hostile Aircraft responses on the Height Range Tube, a system of discrimination was employed which consists of increase in response in both amplitude and width.

Details of Apparatus

Consists of a small Tx in the A/C which is triggered by the pulse from the Radar Tx then indicates pulse at the station frequency every 12 seconds.

Type of IFF Equipment

Mark 1 not used, Mark 2 obsolescent both work on above principles. The short comings of these two is, they can only be used from CH and CHL frequencies. On CH one blip appears every 12 seconds on CHL two blips every 12 seconds. The narrow response was first used on Fighters and later all Allied aircraft. The broad IFF was used for aircraft in distress only. The snags on Mark 2, no use for Centimetre or American equipment which were then being used in this Country with only two frequencies.

Mark 3.

This took over from Mark 2 and was vastly different, has a Fréquency Range of 157 mc/s to 187 mc/s.

The use of IFF interrogator on the ground means you do not need the Radar Console and it can use a different Aerial from Radar Consol. The different Radar Stations had a separate IFF frequency allocated within the IFF Bandwidth. The Rx would only receive a response every 2·8 seconds.

Mark 3 Codings.

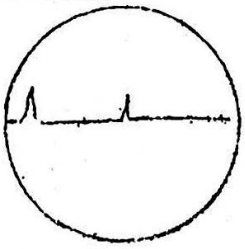
1) Narrow:- Just an increase in amplitude of signal.

2) Broad:- Increase in amplitude and width 6 to 8 miles, Broad IFF from Aircraft means it is in distress.

Both codes 1 and 2 can be used either separately or together to give positive identification. This coupling produced six codes and each of these codes represented various commands or operations.

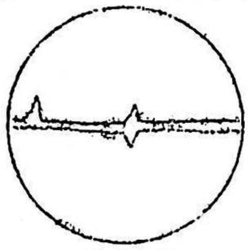
Code 4. Narrow /Narrow / Wide / Wide. Every 2·8 seconds used by aircraft in Contact with or shadowing enemy shipping (Coastal Command)

Code 6. Narrow / Wide / Blank. Used by Fighter aircraft.



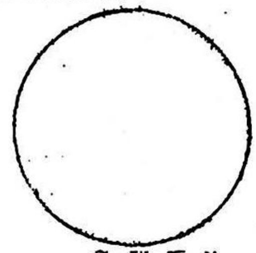
C.H.

Separate Tube for IFF Responses.



C.H.L.

IFF Responses below Radar Responses.



C.H.E.L.

Radar responses on top trace IFF superimposed on bottom trace. IFF on CHEL is shewn every 4 trace

Mark 3.G. Will only respond to the particular aerial of a G.C.I. station. Particular station which it is working with all Fighter Allied Aircraft sheduled to operate with that particular G.C.I. station will have its IFF fitted (plus Mark 3 G) at that aerial 209 mgs. Only switched on at the expressed order from the G.C.I. Controller and the order to switch on is always in code. e.g. Canary. Is designed for use on P.P.I. tube.

Mark 3 G (Castellated Crescent) 

Description of Display.

Appears on P.P.I. Tube as castellations on the crescent image. Every castellation beamed 1/5 arc and lasts for 1/25th sec. Where Radar signal is small or nil, the castellations will appear without crescent.

Main difference between Mark 3 left and Mark 3 G right. Mark 3 used on all types of Radar Station Aerial 157 - 187 mg/s appears every 2·8 secs. Displayed on Height R.T. only A/C IFF Tx on at all times.

Mark III G.

Used on G.C.I. only aerial of parent G.C.I. appears every 5 secs. duration 1/25th second PPI display only Tx in A/C on only when pilot switches on when asked for Canary by G.C.I. Controller. Main advantage of Mark III G. being able to distinguish between friendly Fighters engaged on interceptions of enemy A/C.

Centimetre Equipment

Advantages.

1) Narrow beam width giving much more accurate bearing than CH or CHL
2) Narrow pulse width enables greater accuracy of range.
3) Difficult to jam owing to the high aerial (3000 mc/s).
4) Great sensitivity owing to small wavelength, enabling small object to be picked up.
5) Low coverage enables shipping to be picked up and plotted at considerable ranges.
6) Back radiation eliminated.

Disadvantages.

1) Susceptible to natural interference, i.e. rain, snow wave clutter lightning and cloud of certain types.
2) Window effects centimetre as a jamming device.
3) The lobes are considerably shorter than for radar of greater wavelength, shorter range will be obtained, 120 miles centimetre maximum compared with 200 miles for CH., CHL.

Centimetre Aerial Types.

When the length decreases so the dimensions of the aerial decreases also until at a wavelength of 10 cmts. and less we are able to use solid aerials of such dimensions as to be transported and handled more easily than other types, i.e. CH, CHL. Beamwidth (angle of a paraboloid as worked out by the formula)

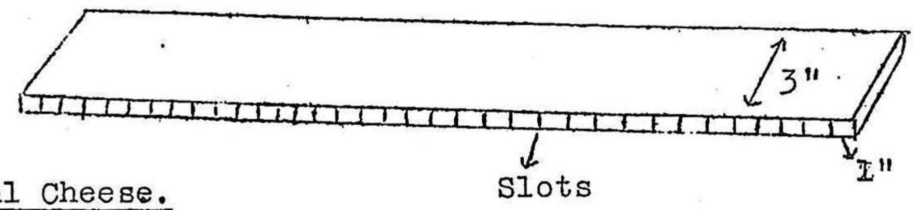
Paraboloid Aerial

front view

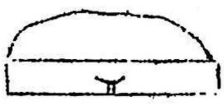
side view

Wave
Guide

Construction of these aerials are of copper or aluminium sheeting or solid rods which make the total area effectively solid. The most common way of feeding these aerials is by the hollow waveguide method (hollow copper tube sometimes silvered internally, which guide the waves from Tx to aerial, and leaves the received echoes back from the aerial to Rx) The switching system between Tx and Rx is the Rhunbatron Gas switch. Dimensions of Waveguide - the rectangular section measurement, the narrow side is 1" wide, side is 3".



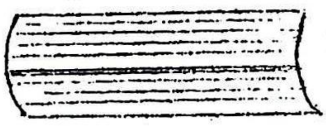
Horizontal Cheese.



10 cms.

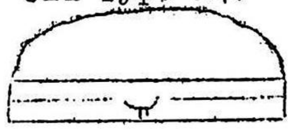
T.14.

New T.14.



Metal Rods.
Wave Guide.

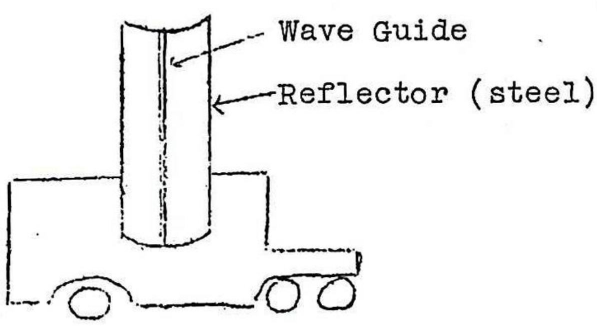
Old Type 14.



Ten cms used for D/F purposes. Low flying A/C both PPI and range tube

Type 13. (Height Finding)

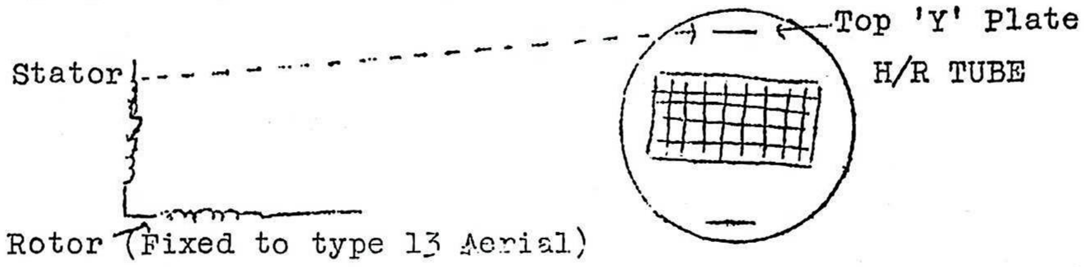
Vertical Parabolic Section.



CENTIMETRE HEIGHT FINDING.

The beam may be elevated by tilting the aerial and by this course the angle of elevation may be obtained. When the type 13. height finding gear is associated with type 14 search gear, the equipment is known as Type 21. Type 11 and Type 13 together is known as Type 22. When 13 aerial is tilted to any particular elevation we must know what this angle of elevation is.

The method of visual presentation of that particular angle is shewn by the position of the H/R trace in the vertical direction (or in the 'Y' axis). Reading height directly through angle of elevation and range means that we must synchronise the movement of aerial tilt with the movement of the trace on the 'Y' axis. Synchronisation of the two is made by the Magslip, this consists basically of two coils, the first the Rotor coil which has a fixed current. Second the Stator coil which picks up energy by induction from the Rotor Coil in varying strength according to the position of the two coils.



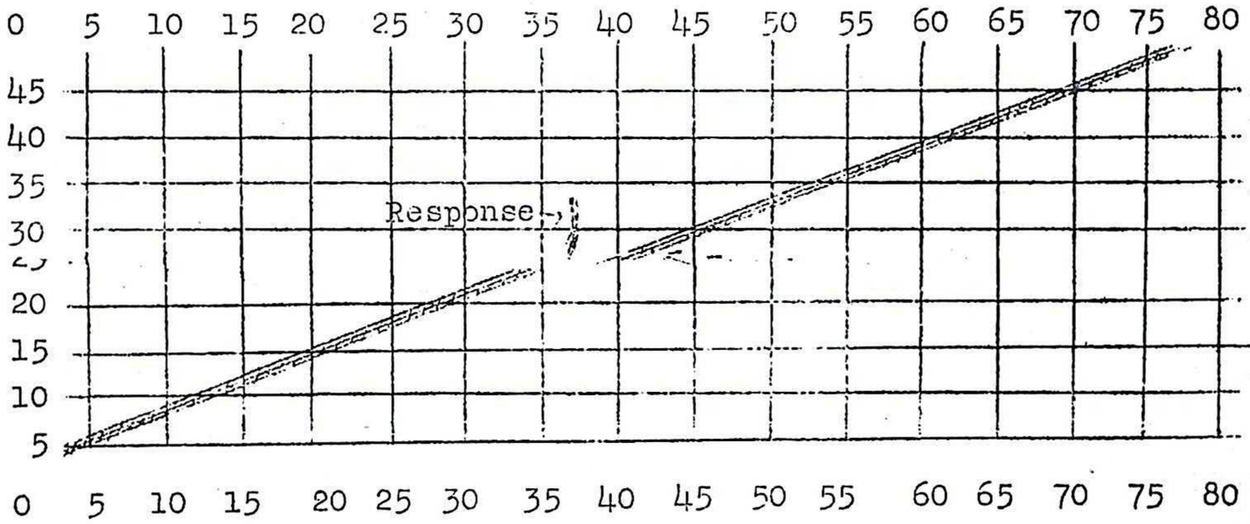
X Sawtooth Sine-wave. Maximum tilt between 25° and 30°. As the voltage on the "X" plate rises taking the spot across the screen to form the trace, so the voltage on the "Y" plates is increased, thus elevating the trace.

The amplitude of the voltage on the "Y" plate is controlled by the magslip and therefore control of amplitude is varied by the variation of the comparative positions of Rotor coil and Stator Coil.

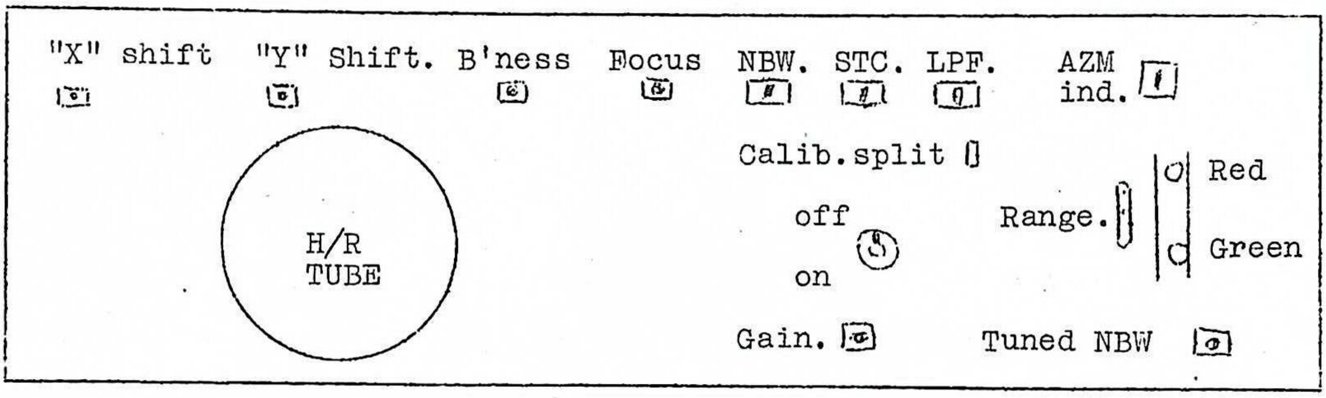
An A/C is found by the type 14 or 15 search gear on the PPI tube. To find the height of this a/c the PPI Operator uses the turning gear controlling the movement in azimuth of the type 13 aerial. To put Type 13 aerial at the bearing of A/C we have a line of light showing faintly on the PPI tube, which corresponds to the bearing of azimuth of the type 13 aerial. To the right of the PPI console is the turning gear of the type 13 aerial, when the PPI Operator turns the handle moving 13 aerial, the line of light moves also.

<u>Beamwidth of Type 13 Aerial</u>

Vertically 2° (Cheese type) horizontal diagram represents a flat fan. Ranges used on Type 13 Aerial 60-80 miles and 80-100 miles with a sweep angle from minus 1° to plus 25°, maximum rate of sweep vertically of 6 per minute.



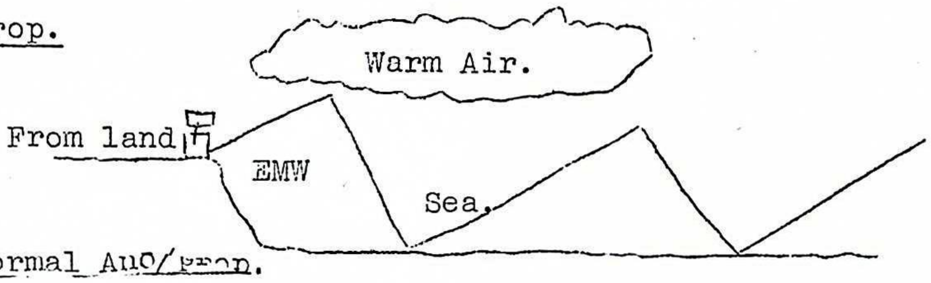
Type 15 Console.



Centimetre Propagation.

Propagation of C.M. waves is affected by weather conditions particularly temperature inversion and humidity.
Temperature Inversion. Under normal conditions there is a decrease of temperature with an increase of altitude. On a hot day the earth heats more quickly than the sea so that the air above the earth is warmer than air above the sea, these lairs of warm above the land may drift out to sea thus making a lair of cold air immediately above the sea and a lair of warm air above that. This is known as temperature inversion. Now the lair of warm air contains a certain amount of water vapour thus causing humidity, and this humidity reflects electro magnetic waves.

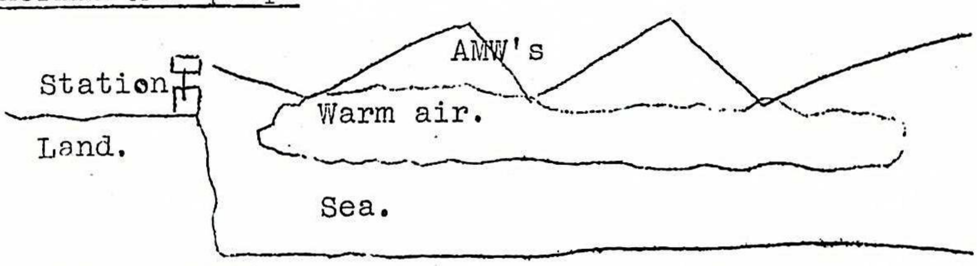
Abnormal Ano/prop.



Effects of Abnormal Ano/prop.

Increased radiation therefore increased ranges, decreased heights for low flying a/c. P.E's not usually seen are recorded on the screen. S/N will increase, responses from shipping and very low flying a/c at abnormal ranges and will be subject to fades and re-appearances.

Sub-normal Ano-prop.



This condition will occur when the humid lair drifts below the level of the Station particulably where the Station is sited on the top of a high cliff.

Effects.

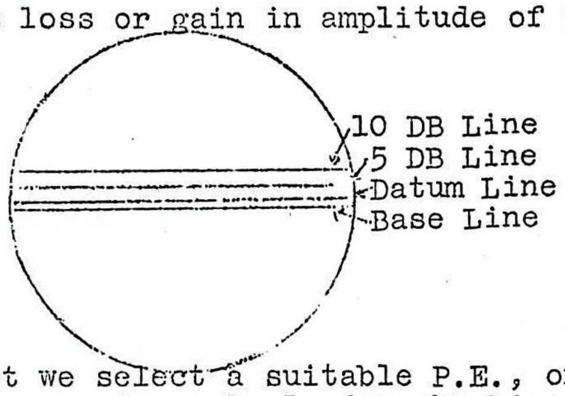
Decreased S/N ratio, increased heights, decreased ranges, no responses from shipping. P.E's will disappear. Whenever Ano-prop occurs it must be reported to the Filter Room, code is used for passing of the information once per hour. The code is - N-normal conditions, B - Abnormal ano-prop present but not severe, A - severe abnormal ano-prop, S - Subnormal ano-prop.

Decibel Calibration.

1 Bell equalls loss or gain in amplitude of 90%

1 Decibel equalls loss or gain in amplitude of 9% of the received signal.

DB Scale



Gain Control

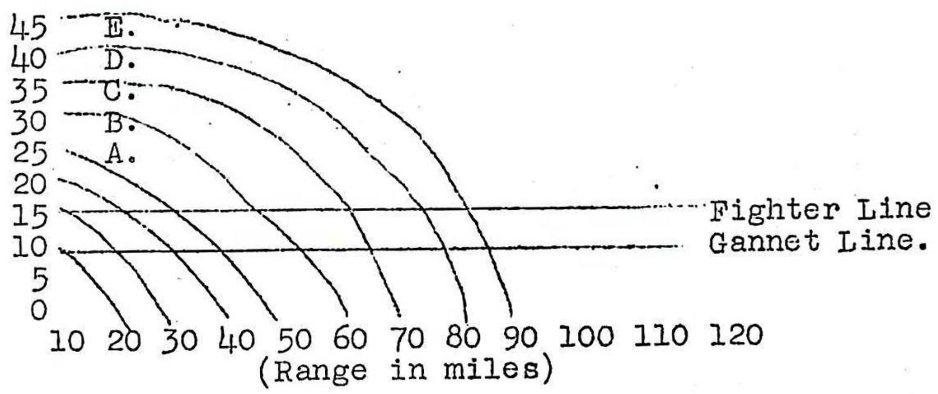
To calibrate first we select a suitable P.E., one with a gently sloping side, and is also used regularly for checking purposes. Then remove gain control and fix a squabe sheet of paper on the console and cover it with perspex, fix a pointer to the gain control and replace knob. Take aerial of power turning and rotate by hand. (a) Turn gain control until noise is level with Datum Line. Inch aerial into P.E's until echo of 5 D.B's is received. (b) Turn down gain control until echo reaches Datum Line, mark on perspex where indicator points 5 D.B's. (c) Inch aerial until response again reaches 5 D.B. Line. Repeat process until calibration of gain control is completed, as gain control reaches minimum D.B. readings tend to come closer together on the perspex sheet. Calibrate in steps of 5 D.B's.

Decibel Correction

Zero becomes 6 D.B's. 5 D.B's becomes 9 D.B's. 10 becomes $12\frac{1}{2}$ D.B's. 15 becomes $16\frac{1}{2}$ D.B's. 20 becomes 21 D.B's.

Taking D.B. Readings of a Shipping Response.

D.B. Chart.



A - Equal to Fishing Smacks (MTB's) B - Equal to Destroyers.
C - Equal to Cruisers. D - Equal to Battleships. E - Equal to very large ships.

1. Turn aerial until maximum echo is reached.
2. Turn gain control down until the average point is level with Datum Line.
3. Note D.B. reading on gain control scale.
4. Read maximum beating of echo against D.B. scale on CRT.
5. Add together the two D.B. readings and this will give you the total Decibel reading for particular shipping response. Knowing the D.B's and range, size estimation can be obtained from the D.B. Chart.

Standard Composite Value.

D.B. estimation of size and tonnage is only accurate when performance of set is the same as when the chart was made. In order to check the performance the centimetre Station has what is known as a Station Composite Value - a figure arrived at when the set is first calibrated in D.B's.

How Obtained.

Six steady P.E's are selected and D.B. readings are taken hourly on all six for 14 days. The steadiest 3 P.E!s are selected and an average value of each one calibrated. Then the average of the three individual average is taken and this is the Standard Composite Value. To check this, the D.B. readings on the 3 P.E's are taken and the average value found and compared with the composite value, and according to whether the performance is up or down, so a correct figure is found.

---ooo000ooo---

MC.

SECRET

LECTURE PRECIS 3512 F.C.U. EXETER.

A.N./F.P.S.3.

1. INTRODUCTION

(a) A.N./F.P.S.3 is an American radar gear which has been adopted by Fighter Command for raid reporting and interception control. It is a long range gear, but only gives plan position and thus if heights are required a height finding gear, i.e. T-13, is usually sited at the same unit.

(b) A small number of A.N./F.P.S.3's have been deployed around the south and east coasts of the United Kingdom, stretching from northern Scotland to Portland. They are employed in varying roles, some as independent Raid Reporting Units, some at C.E.W. stations and some at G.C.I. stations.

2. SITING.

(a) There are three separate sections to an A.N./F.P.S.3 station :
(i) The Operations Room.
(ii) The Power Room.
(iii) The Aerial Head.

(b) A.N./F.P.S.3 should be sited on a level site free of obstuctions and on high ground. The ideal site is on top of a mountain which has a commanding view - Portland Bill Provides an excellent site.

3. RADAR.

(a) The aerial comprises of a 40ft by 16ft paraboloid reflector consisting of metal lattice work and is fed by four homed waveguides.

(b) Two transmitters and two receivers are used, one transmitter and one receiver sreving the "upper beam system" through the three lower waveguides and the other transmitter and receiver serving the "lower beam system" through the top waveguides. The horn waveguide feeding the lower beam system is situated at the focul point of the reflector, giving a highly concentrated beam in both planes. The horns feeding the upper beam system are situated slightly below the focul point so that the upper beam is concentrated in the horozontal plane, but spread more in the vertical plane. The beams may be used at the P.P.I. either independently or together.

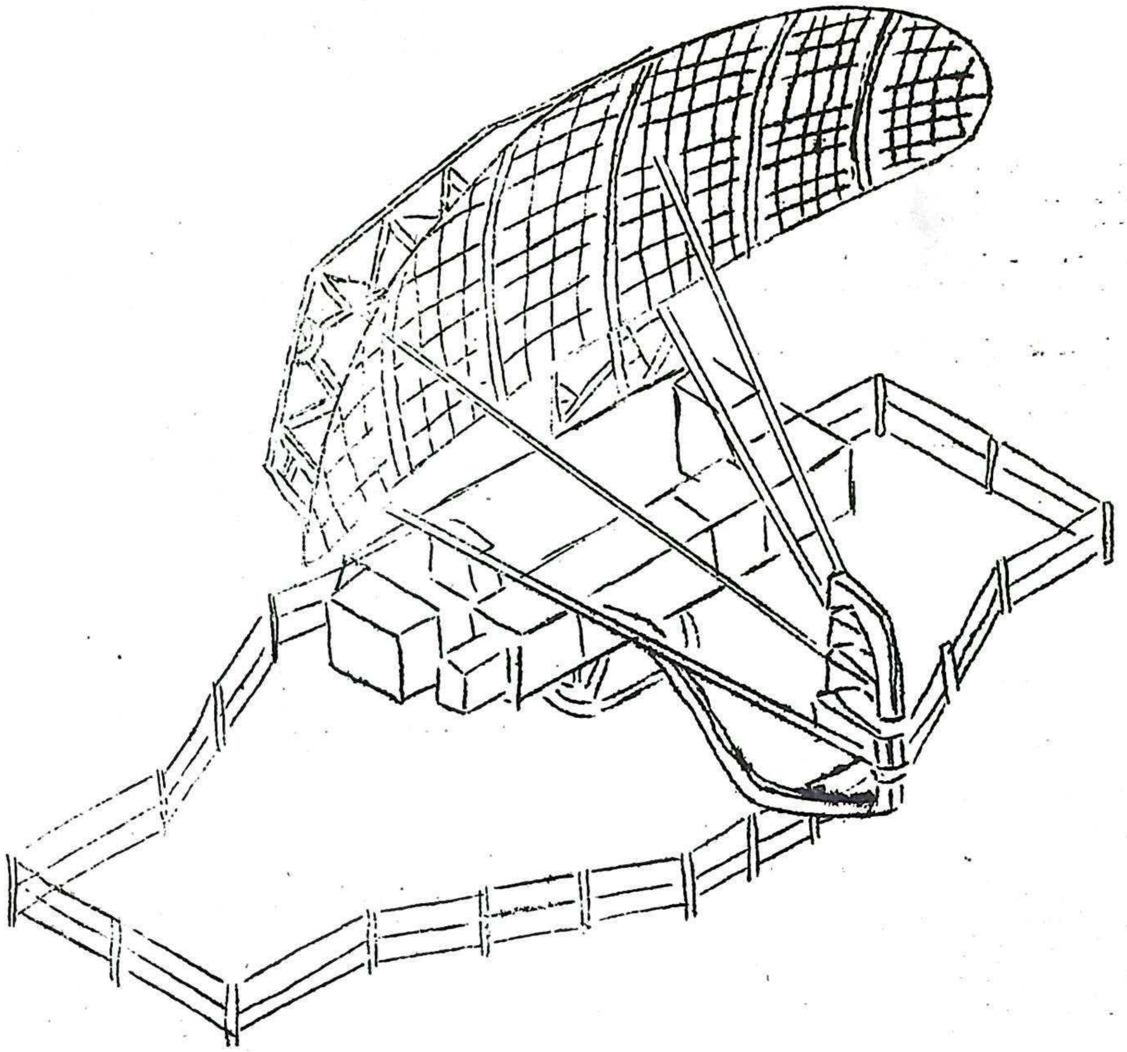
(c) The beam widths are:

(i) Upper beam system; 1·3° azimuth: 15° elevation.

(ii) Lower beam system; 1·3° azimuth: 3° elevation.

The aerial rotation speed can be selected to any one of the following speeds in revolutions per minute : 3·3 r.p.m. ; 5·0 r.p.m.; 6.6 r.p.m.; 10 r.p.m. The aerial may be tilted by the remote control from the radar office to elevations from - 0·5° to + 6·5°. Transmission is limited to the line of sight, therefore a gap below the lobe appears beyond the optical horizon whatever the angle of tilt

(d) Any frequency between 1215 mc/s and 1365 mc/s (corresponding to wavelengths of 25 c.m. and 23·5 c.m. respectively may be used. The frequency can readily be changed from the radar office, this providing a useful anti-jamming device. Both transmitters pulse together.



Lower beam---- Single horn feed

Upper beam -- Three horn feed

AN/FPS-3 AERIAL SYSTEM

3. (d) cont.

The p.r.f. can be chosen at either 400 p.p.s. or 200 p.p.s. giving pulse widths of 3 microseconds and 6 microseconds respectively. The former is used for short range (150 n.m.), the latter for long range (300 n.m.)

(e) An indication of the performance of A.N./F.P.S.3 is given by the performance diagram attached to the precis. Range accuracy is ± 1 n.m. and azimath accuracy is ± 1°. Two objects on the same bearing are distinguished providing the distance between them is not less than 1,000 yds. in range.

(f) The lower frequency at which A.N./F.R.S.3 works gives it greater freedom from cloud clutter, rain and atmospheric phenomena than 10 c.m. gear. It is, however, affected by ground obstructions which cause P. E.'s (but note the use of M.T.I.- see below).

4. MOVING TARGET INDICATOR.

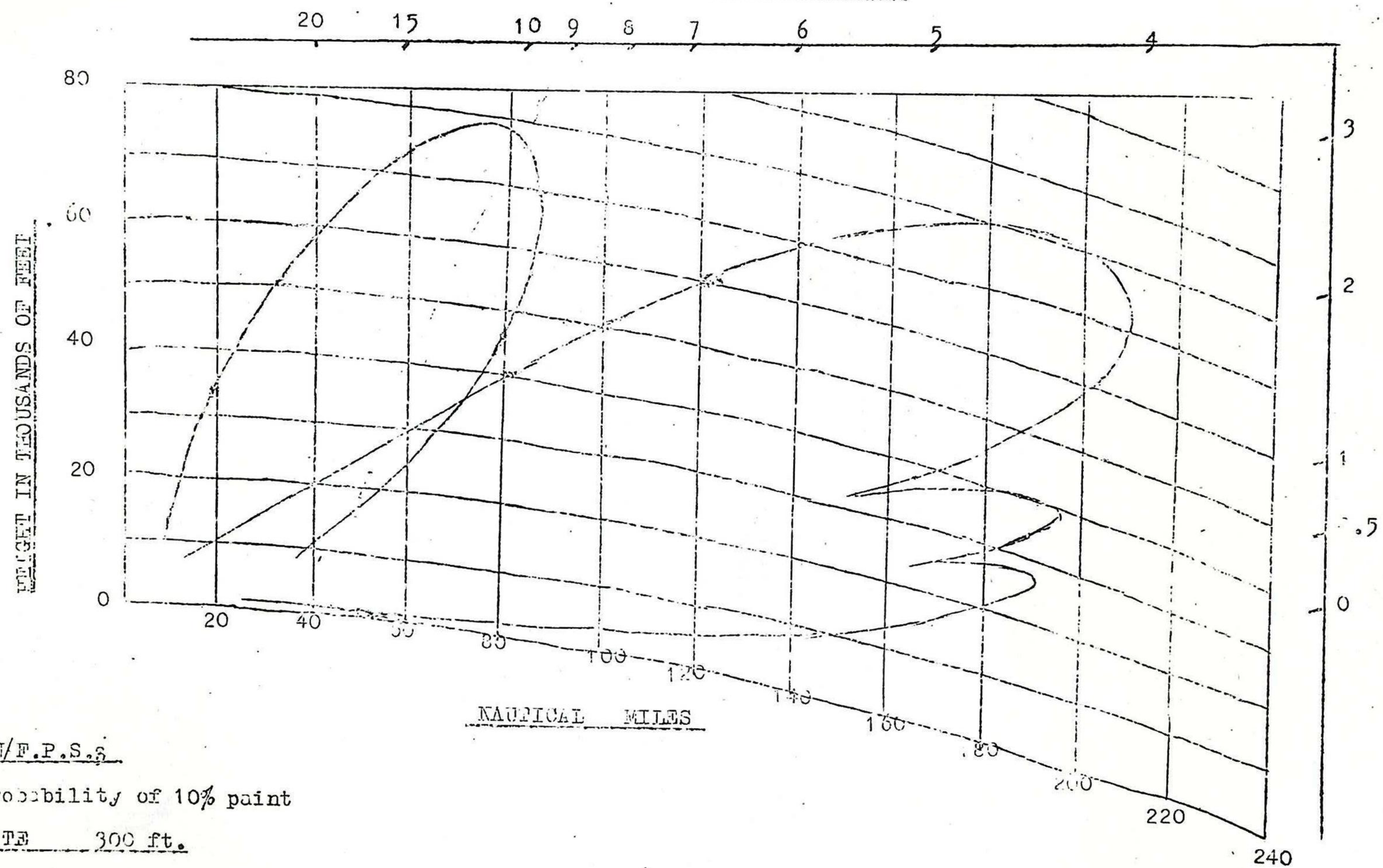
(a) The Moving Target Indicator (M. T.I.) is a devise incorporated in A.N./F.P.S.3. which suppresses partially or wholly echoes from objects whose radial speed, relative to the station, is zero or objects whose radial speeds are exact integral multiples of some specific speed. For example, a particular application of M.T.I. may suppress echoes from objects whose radial speeds are 0, 120, 240, 360, 480, 600, ------knots. This latter application is of little practical significance, but by supressing objects whose radial speed is zero it is possible to eliminate P.E.'s.

(b) M.T.I. can only be used with A.N./F.P.S.3 at a p.r. f. of 400 p.p.s., and this can only be used for ranges up to 150 n. m. the signal strength of echoes from some moving objects is reduced (depending on their radial speeds) when M.T.I. is used.

(c) The basic principle of M.T.I. is that any two consecutive echoes received from an object must vary in azimath and/or range, providing it is moving (its movement consisting of two components Radial and Tangential), by comparing the two echoes, they can be eliminated electronically under certain conditions. The first echoe is fed into the M.T.I. where it undergoes a time delay, the second echoe coming in is fed into M.T.I. without timedelay, but in opposite phase to the first echo. If the echoes come in on the same radial bearing (Radial Speed zero) or on a preset change of bearing (Radial Speeds exact integral multiples) they are suppressed.

(d) It will be seen that the use of M.T.I. in suppressing P.E.'s is an advantage, but the limitation is a reduction in the strength of all signals whilst it is in use and a possible loss of echoes from objects with high tangential speed but low radial speeds.

[illegible] PERFORMANCE DIAGRAM OF A TYPICAL AN/F.[illegible]-3 INSTALLATION



AN/F.P.S.3

Probability of 10% paint

SITE 300 ft.

AERIAL TILT 20

LECTURE PRECIS 3512 F.C.U. EXETER

A.N./F.P.S.3.

5. **ANTI-JAMMING.**

Special anti-jamming devices are incorporated in A.N./F.P.S.3. and may be switched in from the radar office. M.T.I. provides a useful anti-jamming device, especially with regard to "Window". The variable frequency provides a useful antidote to C.W. The following types of jamming may be dealt with :-

(i) Continuous Wave (C.W.)

(ii) Window.

(iii) Modulated jamming (Tramlines
(Criss Cross
(Railings.

6. **DISPLAY.**

(a) Normally the signals from an A.N./F.P.S.3. are fed to a battery of from four to twelve P.P.I. displays. Each display is independent and thus they may each be used for different aims (e.g. long range lower beam search, short range, lower beam search, upper beam search, etc., - - - - -).

(b) The range displayed can be chosen at 50 n.m., 150 n.m. or 325 n.m. and the minimum range at any value from 0 to 240 n.m. Range numbers are at 10 and 50 miles invervals, the latter showing up brighter than the former. "Video Mapping" is incorporated, this is an electronic grid and map which is painted by the trace and always gives true reference no matter what range is selected - range markers are similarly produced by selection. The display may be off- centred in any direction and its scale contracted or expanded as desired.

7. **FUNCTION.**

(a) When set up as an independent A.N./F.P.S.3. station within the Raid Reporting organisation its function may be :

(i) Early warning of the approach of high and medium flying aircraft.

(ii) Overland reporting.

(iii) In another role - provision of P.R.W. information.

(b) When part of a C.E.W. station the function of A.N./F.P.S.3 gear is:

(i) Early warning of the approach of high and medium height aircraft.

(ii) Provision of P.R.W. information.

S E C R E T.

LECTURE PRECIS 3512 F.C.U. EXETER

A.N./F.P.S.3.

7 FUNCTION cont.

(c) A. N. /F.P. S.3 may also be used for control purposes as part of a normal G.C.I. station and when independent or associated [illegible] as an extra control room for a larger G.C.I. station, e.g. [illegible] F.P.S.3 under [illegible].

I.H.H.

RADAR TYPE 13 (CENTIMETRE HEIGHT FINDER)

Introduction.

Radar Type 13 Marks 6 and 7 consists of an elevation-scanning aerial mounted upon a cabin which is capable of being ratated through 360°. The cabin houses the Transmitter and Receiver and the associated I.F.F. equipment(Mark 6 only.). The term "Radar Type 13" specifically applies to the cabin and aerial system only.

The aerial and cabin are remotely controlled from the height finding and associated consoles in the Operations Block.

Function.

The function of Radar Type 13 is to provide height-finding facilities. Type 13 may be used at either Radar Reporting or G.C.I. stations.

Characteristics.

Wavelength..............10 cms.
Frequency...............3,000 mc/s
Aerial..................Vertical parabolic grid reflector; slotted wave-guide feed
Beam Width (Horizontal) 5°
Beam Width (Vertical) $1\frac{1}{2}$°
P.R.F...................500 pulses p/sec.
Pulse width.............0·6 / 1·9 microsecs
Range...................calibrated to 150 naut.miles and 60,000ft. in altitude.
Nodding Limits..........between −1° and +20° (Height-finding is, however, only possible from about $+\frac{3}{4}$° to +20°)
Nodding Rate............10 cycles per minute (1 cycle in 6 secs.)
Discrimination..........
Mounting................Rotatable mounting (cabin) remotely controlled from the display console (Type 61).
Site....................broken ground
Accuracy................±500 ft.
Bearing.................very accurate.

Components.

Radar Type 13 consists of the following components:-
(a) Slotted (leaky) wave-guide
(b) Gridded reflector
(c) Cabin (housing main TX & RX & I.F.F. equipment)
(d) I.F.F. "A" Band aerials (attached to Mk.6 only)
(e) Turning gear and Slip Ring unit.

(a) Wave guide.

The wave-guide consists simply of a rectangular box, 20'x3"x1". The guide is situated at the focal point of the reflector. On the inside (side facing the reflector) of the wave-guide, 100 slots are cut, through which the radio energy passes to and from the target.

The purpose of the slotted wave guide is to give a suitable linear feed alon the focal line of the reflector. To give a reasonable compromise between maximum and minimum side lobes, it is preferable to provide a tapered feed along the length of the reflector, such that the power radiated at the centre is about 4 times that radiated at the ends. Such a tapered feed can be obtained by cutting slots in the narrow face of the wave guide. These slots are spaced roughly $\frac{1}{2}$ wavelength. The intensity of the radiation in the wave guide decreases as the far end (opposite to the TX end) is approached, due to extraction of energy by successive slots; an increasingly greater percentage of energy remaining must be extracted by the slots the further away they are from the feed end, to ensure a constant amplitude of energy fed into the reflector along all points of the wave guide. This is achieved by increasing the angle of tilt to the vertical from one slot to the next, those at the load end being nearer horizontal that those at the feed end. This angle of tilt varies from 4° to 17°.

Angle of Squint.

So that a narrow beam in the vertical plane may develope, the slots are situated slightly more than $\frac{1}{2}$ wavelength apart. The actual spacing used is 200° of phase (0.55 wavelength) This has, however, the effect of causing the beam to incline from the normal of the beam in the direction of the "load" end.

The angle of squint varies between 5.7° for a wavelength of 9.8 cms. to 2.9° for a wavelength of 10.2 cms.

The slots in all extract about 95% of the total energy from the wave guide. The remaining 5% is absorbed by the "load" at the end of the guide. This load is composed ofsand cement and graphite.

To weatherproof the linear array, the wave guide is enclosed in perspex. To render the wave guide moist-free at all times, a current of dry,warm air is blown along inside the perspex cover.

To allow for ascillation of the aerial, a simple oscillating joint, known as a tubular feeder, is used. This consists essentially of the rigid end of the aerial wave guide being "fostered" to the feeder guide from the TX by use of ball-bearings.

Reflector.

The reflector which is 20' x $5\frac{1}{2}$' is made of steel rods $\frac{1}{2}$" in diameter and spaced at a distance of 1½inches.

This type of reflector is directive in the horizontal plane, since it has a parabolic section in that plane. In the horizontal plane, directivity is obtained by using a linear array. This array produces horizontal polarization and it is possible therefore, to construct the reflector of vertical steel tubes.

I.F.F. "A" Band.

Radar Type 13 Mk.6 is fitted with Mk 111 A I.F.F. The installation consists of:-

(a) An aerial array (Common TX and RX)
(b) An interrogator (Low Power Transmitter)
(c) Two Receivers.

Aerial Array.

The aerial array is mounted adjacent to, and rotates with, the main Radar Array. The system normally works in conjunction with the airborne Transponder (Transmitter/ Receiver) Mk. 3 GR. Identification pulses are discharged on the height range C.R.T. of the main radar console.

I.F.F. Mk 111 A works on a fixed frequency of 187 mc/s, between 157 mc/s and 187 mc/s ("A" Band). The airborne transponder sweeps through the band in $2\frac{1}{2}$ secs., with one additional $\frac{1}{2}$sec. for a suppressed flyback. A reply is therefore transmitted on any one frequency every 3 secs.

The reply from the transponder is coded by varying the pulse width and the sequence in which the responses of different pulse width are radiated. The code consists of a combination of narrow, wide and missed responses, and the coding cycle is completed in 4 responses. In addition there is a very wide emergency code.

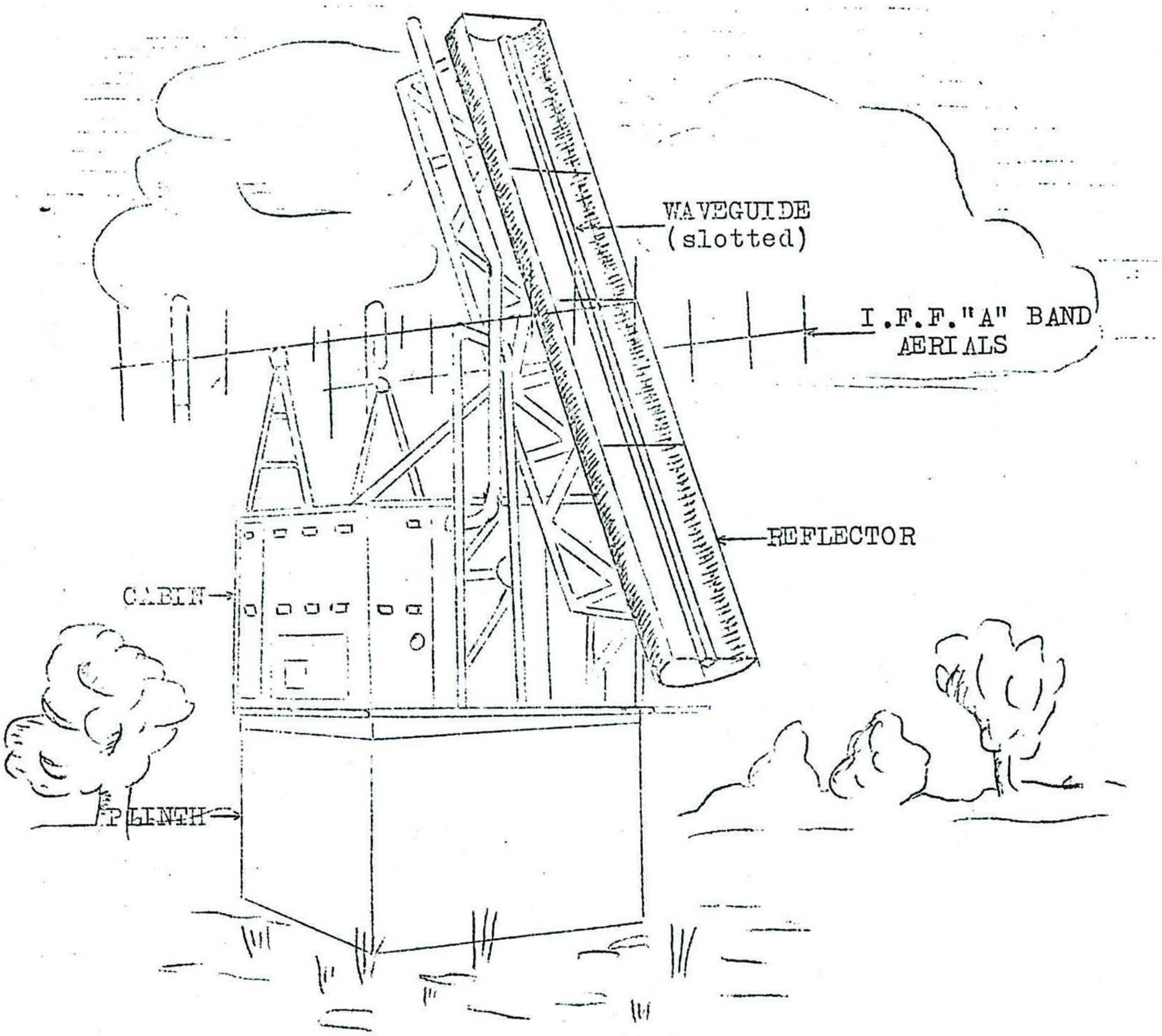
As the response is only obtained every 3 secs., it is necessary to stop the ground I.F.F. aerial and "look" at the aircraft to be identified. The time to observe a complete coding cycle equals 15 secs.

Aerial System.

The aerial system comprises two vertically polarized "YAGI" Arrays, positioned one on each side of the main radar paraboloid. Each array consists of :-

(a) 1 Folded dipole ($\frac{1}{2}$ wavelength in length)
(b) 1 Reflector
(c) 9 Directors.

For a further development of I.F.F. see the precis entitled I.F.F.



TYPE 13 Height-Finder

RADAR TYPE 14 Mks 8 & 9.

Introduction.

Radar Type 14 consists of a scanning aeriel mounted on a cabin which is capable of being rotated through 360° thus providing all round coverage. The cabin which is either mounted on a plinth or a gantry (See heading "Characteristics") houses the main TX and RX and associated IFF equipment.

The term "Radar Type 14" specifically applies to the cabin and aerial system. This type of equipment is installed at C.E.W., C.H.E.L. and G.C.I. stations.

Radar Type 14 consists of two MARKS, namely Mk 8 and Mk 9. Basically, both marks are identical in construction with the following exceptions:-

(a) The reflector of the Mk 8 gives a $Cosec^2$ radiation pattern. This results in the reflector being not a true parabola bu having a "lower lip" as it were, thus providing high coverage.
(b) Mk 9 is situated on a 25ft gantry, thus providing extra low coverage.
(c) Mk 8 uses both "A" and "G" band IFF.
(d) Mk 9 uses "G" band IFF.

Characteristics.

Subject	Type 14 Mk 8	Type 14 Mk 9
Wavelength	10 cms. "S" BAND	10 cms "S" BAND
Frequency	3,000 mc/s	3,000 mc/s
P.R.F.	500 p.p/s	250 p.p/s
T.R.F.	500	250
Pulse Width	0.6 1.9 microsecs	0.6 1.9 microsecs
Horizontal Beam Width	$1\frac{1}{2}^{\circ}$	$\frac{1}{2}^{\circ}$
Vertical Beam Width	8°	$4\frac{1}{2}^{\circ}$
Revs. per minute	0 - 6	0 - 6
Aerials	Horizontal parabolic grid reflector of the $cosec^2$ pattern type (Lower lip) with leaky guide. Common TX & TX	Horizontal paraboli grid reflector wit slotted wave guide. Common TX & RX
Coverage	3° - 25° in elevation	9° - 3° in elevatic
Bearing Assessment	Rotating Beam	Rotating Beam
Reflectors	untuned	untuned
Type of site	saucer-shaped or hill crest.	saucer-shaped or hill crest.

Components.

Radar Type 14 consists of:-

(1) Slotted wave guide
(2) Gridded reflector
(3) Cabin housing TX & RX and IFF equipment
(4) IFF aerial array
(5) Slip Ring unit and turning Gear.

(1) Slotted Wave guide.

[illegible] horizontal plane directivity is obtained from the wave guide [illegible] dimensions are 25' x 3" x 1". The guide effectively consists of a [illegible] number of point sources of radiation all radiating in such a way tha [illegible] variation along the array is linear.

The percentage of energy extracted from the guide depends upon the inclination of the slot to the vertical, this being zero when the slot is vertical and increasing as the angle of inclination to the vertical increases.

The radiated power is polarized longitudinally, that is in the direction of the length of the wave guide. Since the intensity of the radiation in the waveguide decreases as the far end is approached due to extraction of enercy by successive slots, an increasingly greater percentage of energy remaining must be extracted by the slot the further away they are from the feed end to ensure the correct amplitude of energy fed into the reflector at all points along the waveguide. This is achieved by increasing the angle of tilt to the vertical from one slot to the next; those at the termination end being nearer horizontal than those at the feed end.

In practice, a uniform distribution of power from one end of the array to the other is not desirable.

It is preferable to have a distribution which tapers from the centre to the edges in order to compromise between the narrowness of the main beam and the smallness of the side lobes. Slot inclination is therefore chosen to give a 4 : 1 power taper.

A total of 96 slots are used. In order to keep the radiation in the correct phase relationship, slots are anti-phased by being inclined at opposite angles to the vertical. This compensates for the phase change brought about by the spacing of the slots being almost half wavelength.

If the slots were exactly 180° in phase apart, slight mismatches at each slot would biuld up, thus causing a high standing-wave ratio. To prevent this the slots are spaced slightly greater than half wavelenght. This extra spacing however, causes the beam to deviate from the normal, known as the angle of "squint." The beam is always inclined towards the load end of the array.

In order to compensate for the angle of squint, it is arranged that the IFF array is inclined to the length of the cabin at an angle of 4°. This ensures that the direction of the IFF beam coincides as nearly as possible with the much narrower radar beam. (The angle of squint is approx 4°.)

The slots extract about 90% of the total energy in the waveguide, the remaining 10% being absorbed by the load.

Gridded Reflector.

Type 14 Mk. 9 reflector is to all intents and purposes the same as that of Tupe 13 Mk 6 & 7 with the exception that the physical dimensions of the Type 14 Mk 9 are 25' x 8'.

Mk 8 Reflector.

As already stated the Type 14 Mk 8 reflector was described as a "distorted parabola" having a lower lip for high looking purposes.

In searching for aircraft in azimuth it is desired to produce a beam shape which is sharp in azimuth but shaped in elevation. The object of the latter requirment is to illuminate aircraft at constant hieght with a pattern which produces a constant amplitude of echo for a large variation of of angles of elevation, thus using the power available in the most economical manner. The ideal pattern is shown in Fig. 3.

Cosec. squared.

IN order to provide a feed minimum of illumination on the aircraft along the upper contour of the coverage diagram, it is necessary for the amplitude pattern from the aerial to coincide with the diagram shown in Fig. 4. In this $r = h \operatorname{Cosec} \theta$ so that the amplitude pattern is proportional to Cosec θ, or the power pattern is porportional to $\operatorname{Cosec}^2 \theta$.

It should be noted that in the expression "cosec. squared aerial", "cosec squared" refers to the shape of the power amplitude diagram and not to the shape of the reflector by which it is produced.

I.F.F.

Both MARKS of Radar Type 14 are fitted with I.F.F. in either of two variants, depending on the application of the radar station.

Static Application.
In the static application such as Hope Cove G.C.I. and Portland C.E.W. Mks 8 and 9 have Mk 111G I.F.F. installed.

In the mobile application such as 2nd. T.A.F. Mk. 8 has both Mk 111G and Mk 111A I.F.F. in operation.

Mk 111G I.F.F.
The I.F.F. installation consists of:-
(a) Aerial array.
(b) IF.F. TX
(c) I.F.F. RX
(d) Display unit.

Aerial Array.
An 8 element broadside array is employed; the individual elements are end fed dipoles mounted in front of an L-shaped frame, which acts as a reflector and earth screen.

The I.F.F. aerial array is mounted at an angle to the main radar reflector corresponding to the average angle of "squint" of the radar aerial over the "S" band of frequencies.

Display unit.
I.F.F. Mk 111 G enables a G.C.I. station to obtain, on request an identifying signal from an aircraft under its control. When identification is required the I.F.F. TX is switched on from the radar console. At the same time the pilot of the aircraft is requested to switch on the airbourne transponder (TX & RX). The transponder is switched on for a period of 20 seconds, after which it is automatically switched off. If the I.F.F. aerial is rotating at a speed of 6 r.p.m. a response will be seen for two revolutions.
The response from the transponder consists of pulses 12 microsecs. wide transmitted for periods of 1/25 of a sec. with 1/10 of a sec intervals. Due to the small delay period in the I.F.F. system caused by the transponder the I.F.F. response on the P.P.I. occurs roughly one mile behind the radar echo of the aircraft. The I.F.F.response appears as a ring of closely packed spots having the centre of the P.P.I. tube as its centre.

Mk 111A I.F.F.
Mk 111A I.F.F. is identical with the Mk 111A I.F.F. explained in the precis entitled Radar Type 13 with the exeption that the aerial array is as for the Mk 111G I.F.F. installation.

Method of producing cosec squared pattern.

The desired pattern is produced by taking the standard reflector of paraboloidal section as used on Radar Type 14 Mk 9 and distorting the lower half in such a way that incident rays are reflected upwards as opposed to the more usual horizontal direction. This is illustrated in Fig 4.

The shaped reflector, together with the illuminated pattern of the slotted waveguide at F (see Fig. 5.) produces an approximation to the ideal pattern desired. Fig. 5 shows the type of cover diagram produced in practice by the two types of reflector.

RADAR TYPE 7.

Radar Type 7 is a static metric radar equipment employed at G.C.I. stations primarily for use in the ground control of fighters and secondly to provide track telling rooms at G.C.I. stations with overland tracking of selected tracks and additional sea coverage. When used in the latter capacity it is referred to as the C.H.B. element.

The term Radar Type 7 strictly applies to the aerial head and the transmitter well.

There are two types of Radar Type 7 - namely Mks 2 and 3. The only marked distinction between Mks 2 and 3 is that while the Mk 2 is positioned adjacent to the operational block, the Mk 3 is positioned at a distance of approximately 400 yds. from the block.

CHARACTERISTICS OF RADAR Type 7 equipment.

Wavelength	1.48 and 1.51 metres
Frequency	198 and 202 mc/s
Freq. Range	175 to 245 mc/s
P.R.F.	250 and 550 c/s
Pulse Width	3.8 mecrosecs.
Band Width	3 megs.
Int. Freq.	45 megs.
Sweep rate	0 - 6 r.p.m.
Aerial	54 ft. (Length) x 25 ft.
Reflectors	wire mesh
Range	240 miles using a P.R.F. of 250 c/s 120 " " " " " 500 c/s
Range accuracy	$\pm \frac{1}{2}$ nautical mile
Bearing accuracy	$\pm \frac{1}{2}^{o}$
Height accuracy	$\pm$ 500 ft.
Height coverage	2.5^{o} to 20^{o} of elevation
Vertical Beam Width	From 2^{o} to 30^{o} (28^{o} of elevation)
Horizontal " "	8^{o} approx.
Site	Saucer-shaped depression to give high angled coverage and to eliminate long-range P.E.'s.
Transmission Reception	Common transmitter and receiver aerial

Transmitter & Receiver Arrays.

The same aerial is used both for transmitting and receiving.

A framework 54 feet long and 25 feet high upon which is mounted three separate aerial arrays arranged as follows:

Top Array.

(1) An 8-bay, 4-stack array of full-wave horizontal dipoles at a mean height of 25 feet. (32 dipoles)

Middle Array.

(2) Two 8-bay, 2-stack arrays of dipoles at heights of 12½feet (16 dipoles)

Bottom Array.

(3) Two 8-bay, 2-stack array of full wave dipoles at a height of 7½ feet. (16 dipoles)

In each of the arrays the stacks are divided into four bays, each of two adjacent stacks. The distance between the stacks is equal to 1.2 wavelength, the vertical spacing being 0.5 wavelength. Fig. 1 shows the layout of the aerial arrays.

The dipoles are placed 0.11 wavelength im front of the reflector screen which is constructed of wire mesh.

The dipoles are fed alternately, so that all the elements in a stack are fed in phase as shown in Fig 2. Taper feeding is employed; that is, the amount of current fed to the centre dipoles equals twice the amount fed to the dipoles at the extremity of the aerial. This has the effect of reducing the side lobes which give rise to false echoes.

Since it is desired to maintain a very narrow main beam, side lobes cannot be eliminated entirely, so a compromise is reached where a narrow beam is maintained at the expense of a few side lobes.

Capacity switch.

The energy from the Transmitter is fed into the aerials in turn, the returned signal being fed into the same aerial on which it was broadcast and then returned to the Receiver, and finally to the Display consoles. The Capacity switch which is situated at the head of the control colums,(See Fig 1.) is used to switch the energy from one aerial to another. It also is designed to ensure that the aerial in use is left "open" long enough to receive any returned energy from extreme range.

Since the middle and bottom arrays may be combined to form an array at mean height of 10feet,(see Fig.1.) the capacity switch feeds the energy into each array in turn as follows:-

(1)	Top array	25 feet
(2)	Middle array	12½ "
(3)	Middle & Bottom arrays	10 "
(4)	Bottom array	7½ "

Mode of operation.

During transmission, each aerial in turn is fed with radio energy from the transmitter. The Capacity switch switched the radio energy from one aerial to another, holding "open" the aerial long enough to ensure the return of long range reflected energy. The returned energy is returned to the same aerial on which it was broadcast and passed to the receiver, finally appearing on the P.P.I. (Console Type 64.) and Height range tubes (Console Type 65) in the form of a response.

Height Finding.

The hieght of an aircraft is determined by comparing the signal strength received from two aerials at different heights. For purposes of height finding, four aerials at different heights are used, and by the use of the aerial selector switch any combination of two aerials may be used to compare signal strengths.

The aerial combinations used and the selector switch positions are as indicated below:-

	Switch Position	Combination	Aerials.	
(a)	Top	Normal	12'6"	-7'6"
(b)	Bottom	Low	25'	- 10'
(c)	Left	Left Check	10'	- 7'6"
(d)	Right	Right Check	10'	- 12'6"
(e)	Central	All aerials in use.		-

Fig. 3 indicates the aerial selector switch layout.

As each pulse of radio energy leaves the aerial a trace, produced by the spot, appears on the tube face. With the aerial selector switch in the central position, four aerials are used to transmit, thus producing four traces. Since the traces are superimposed, only one trace is apparent on the Hieght rang tube.

When the aerial Secletor Switch is placed in any one of the four positions, other than the central position, two aerials are transmitting, thus producing two trances on the tube.

The retunned signals from both aerials appears on the tube face as an echo. Bu use of the "Split Switch", a small "X" shift is applied to the "X" plates. This has the effect of drawing one of the echoes slightly to the right. The echoes now appear side by side thus affording easy comparison.

The comparison is applied to the "Manuel Calculator" where, in conjunction with the range of the echoes, the hieght is assessed.

Fig 4 shows the layout of the Concole Type 65, The Manual Calculator, the Height range Tube and the Aerial Selector Switch, and the Split Switch are as indicated.

For Type 7 Height Finding see Precis entitled "Type 7 heights."

NOTE:

THE DIPOLES ARE FULL-WAVE.

C.H.

The C.H. or A.M.E.S. Type 1 Station was the first type of station developed. It was originally designed to give the best possible overall cover. To-day the role of C.H. is to give medium and high level cover at long range (plotting commencing at the practical maximum range of Type 7 radars).

RANGE	Three ranges can be selected. 100, 200 or 300 nautical miles.
COVERAGE	Floodlight (60 degrees - 80 degrees either side of L.O.S.) Vertical 1½ degrees to 25 degrees (approx.)
WAVELENGTH	While there is provision for changing to any of four wavelengths the one normally in use at the present is 11.5 mts. (approx.) (Frequency 26.38 mc/s)
P.R.F.	Whilst two P.R.FS. can be selected (25 and 12.5) 25 is the one in normal use.
BAND WIDTHS) PULSE WIDTHS)	A three position band width switch is available on the receiver giving three band widths - narrow 50 k/cs - medium 250 k/cs - wide 500 k/cs. A four position pulse width switch is also available giving three pulse widths - narrow 5 m/secs - medium 8 m/secs - wide 32 m/secs. The other position is "Automati" which automatically adjusts the pulse width to the band width.

AERIALS:-

Separate transmitter and receiver fixed aerials are used. The tx dipoles are slung between two tall steel towers. The receiver dipoles are placed at varying heights on a smaller wooden tower.

DISPLAY:-

The display is presented on an electrostatic range tube on the receiver itself. While only ranges are shown on this tube (no Georef) bearings and heights can be obtained by comparing the strength of signals between two aerials. This is done by a "Goniometer". As this instrument is manually operated, "human error" arises, so that bearings and heights are not always accurate, but ranges are.

The bearings, RANGES & "Theta heights" (as the bearings shown on the goniometer, when heights are required are known) are converted by an electrical calculation to a Georef position and height. These are shown on a display panel and plotted on a perspex table and told to the C.F.P.

Another display console is tapped off the main receiver. This display is a duplicate of the main receiver console without the goniometer and certain other controls. At this console is positioned a "tracker" who draws the plotters attention to tracks which are to be plotted by means of a director pulse, and also keeps a range/time graph on each track.

CREW:-

A C.H. crew consists of:-

(1) Supervisor
(2) N.C.O. i/c watch
(3) Observer
(4) Tracker
(5) C.H. Plotter
(6) Teller
(7) Recorder

C. H.   CHAIN HOME TYPE 1 RADAR.

COVERAGE. 60..80 degrees either side of the Line of Shoot.

RANGE. Approximately 200 miles.

HEIGHT. Approximately 55,000 feet.

FUNCTION To detect long range high flying aircraft.

ACCURACY. Correct in range but NOT ALWAYS IN BEARING.

TECHNIQUE. Floodlight, from static aerials.

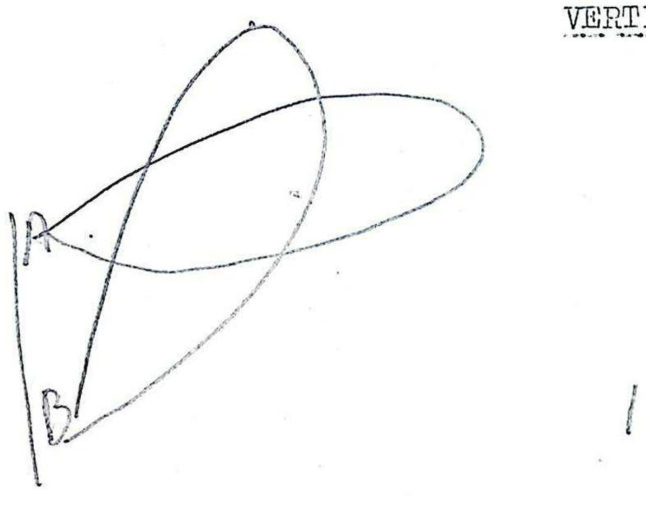
Site - Usually ~~sited~~ on or near coast.

The static curtain array is slung between two 360'0" towers. Energy is induced through the dipoles and radiation is set up. Reflectors placed a quarter of a wave length behind the transmitting dipoles cause the energy to be directed over sea.
The curtain array comprises two systems. "A" at 240 feet consisting of eight dipoles and "B" at 95 feet consisting of four dipoles. They transmit alternately for 5 micro seconds and cannot transmit together.

"A" system is used to detect high flying long range aircraft.

"B" " " " to detect very high flying shorter range aircraft.
An aircraft in the field of energy will cause a portion of the energy to be reflected back to the receiver tower where it is received on the appropriate "A" or "B" dipole and fed down the "feeder" lines into the Cathode Ray tube in the C.H. Receiver Cabin. The aircraft appears as a small "V" on the Horizontal Time Base, and is "D/F'd" to a MINIMUM by use of the GONIOMETER and the range determined by moving the RANGE MARKER along the RANGE SCALE to a point at the top left hand edge of the now barely visible "ECHO". Range plus bearing are fed into the calculator and a fighter grid plot obtained. This is passed into the T.P.T. and due to the human element or error in operating the Goniometer FILTERING is necessary to determine the aircraft position. Heights are obtained by selecting the height button and use of the calculator.

VERTICAL COVERAGE DIAGRAM.



GROUND RAY is caused by the direct transmission of energy from the transmitter to the receiver, also called SATURATION.

P.E's are permanent echos or objects permanently in the field of energy, Many stations use their own P.E's for assisting calibration.

C.H.E.L. CHAIN HOME EXTRA LOW.

Introduction.

C.H.E.L. or "Chain Home Extra Low" is the term applied to coastal Radar reporting stations which make use of centimetric types of radar equipment, notably Type 14 Mk. 9 and Type 54 for the purpose of detecting low flying aircraft and shipping.

C.H.E.L. equipment may be combined with C.E.W. equipment where it becomes a C.E.W./C.H.E.L. station or may be sited independently of other radar stations where it functions under to name of an independent C.H.E.L. station.

Function.

The function of a C.H.E.L. station is:-

(a) To provide warning of the approach of low-flying aircraft (RATS) passing the information direct to the S.O.C.

(b) The reporting of low and medium flying aircraft from a range maximum directed by H.Q. F.C.

(c) The reporting of surface vessel activity.

Components of a C.H.E.L. station.

The following are the main components of a C.H.E.L. station:-

(1) Aerial array (reflector and waveguide)

(2) Display units (housed in Ops. Block)

Characteristics.

As already pointed out, C.H.E.L. uses Type 14 Mk 9 to provide low coverage. This type of radar equipment has been adequately dealt with in the precis entitled Radar Type 14 Mk. 8 & 9, it is therefore sufficient to describe Radar Type 54 which is the other main type of C.H.E.L. equipment.

Subject	Radar Type 54.
Wavelenght	10 cms.
Frequency	3,000 mc/s
Horizontal Beam Width	2°
Vertical " "	2°
P.R.F.	500 p.p/s.
T.R.F.	500 .
Pulse Width	.6 & 1.9
Aerial	Paraboloidal Sheet Steel reflector (saucer shaped) with open waveguide feed.
Bearing	Rotating beam
Mounting	210 ft. tower
Rotation	0 - 6 r.p.m.
Coverage (surface)	40 - 45 naut. miles (greater detection possible)
Vertical coverage	sea level to 8,000 ft.
Range discrimination	400 yds. (a/c on same bearing)
Bearing Discrimination	2°
Desing coverage	Beam search in azimuth, at low, very low, and low medium angles of elevation medium range.

Aerial Array.

Reflector.

The reflector which is made of sheet metal, is parabolic or dish-shaped.

Its diameter is 10 ft. The reflector and associated TX and RX are situated at the top of a 200ft. tower. Gale force wind may stop the rotation of the reflector.

Wave-guide.

The waveguide which conveys the radio energy to and from the reflector is of the open feed type. It consists of a rectangular copper bar with one end opening into the focal point of the reflector.

Display Unit.

For a full description of the display units, see precis entitled "C.H.E.L. Display units."

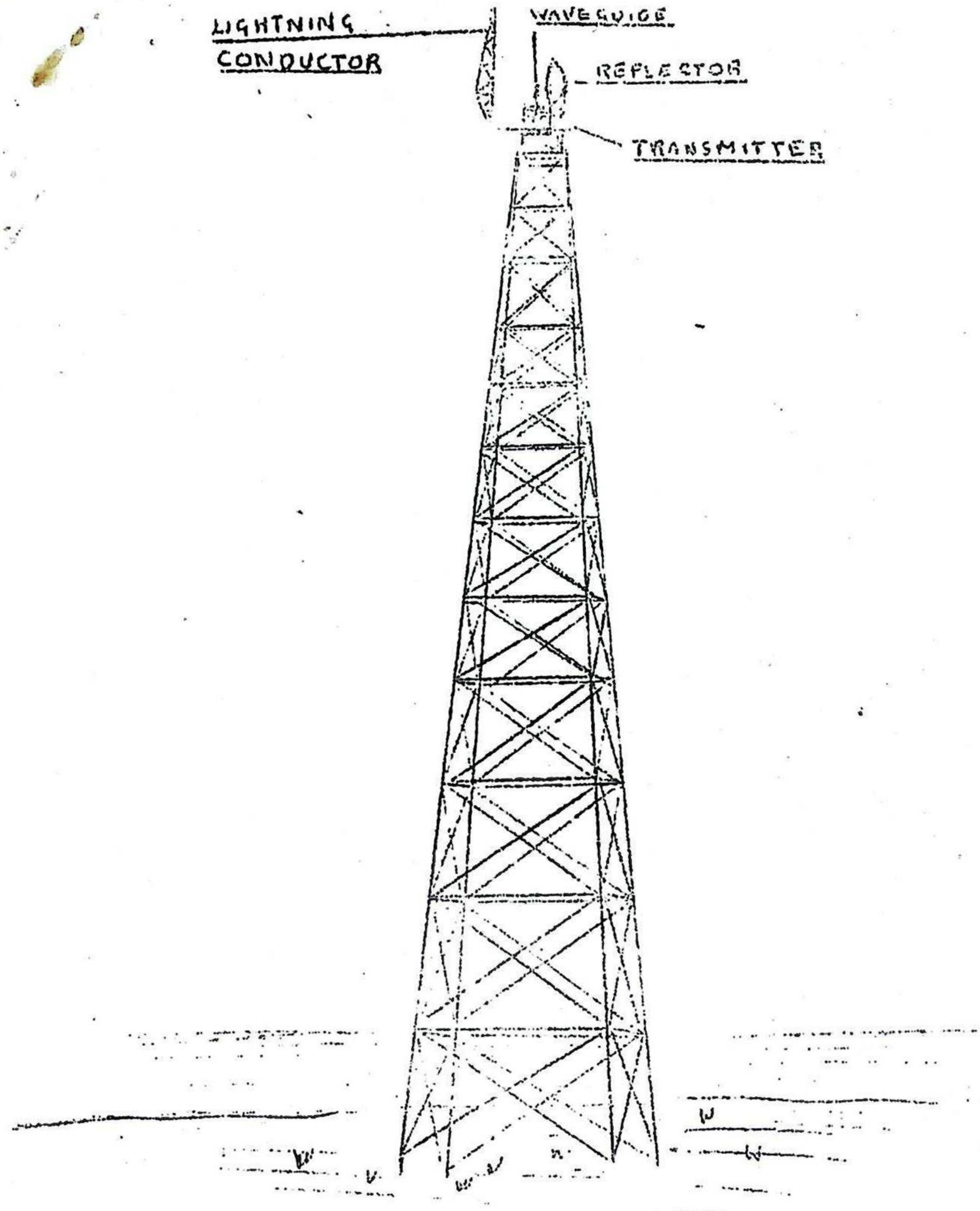
NOTE :

1. Future orginisation of the Air Defence System proposes the use of T.54 equipment at C.H.E.L. Stations only.

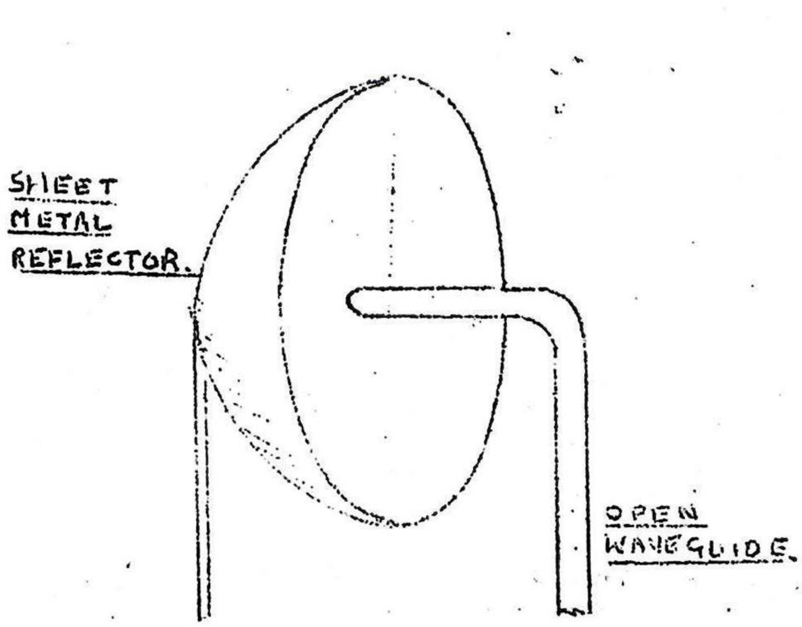
2. I.F.F. T.54 Mark.III is used at G.C.I. Stations. No I.F.F. facilities are incorporated.

   T.54 Mark.II is used at Coastal Reporting Stations and uses both "A" & "G" Band I.F.F.

3 C.H.E.L. Stations play the minor roll of passing NEWBEX Reports to the Meteorological Office .



TYPE 54



AERIAL MOUNTED ON 200ft TOWER

COVERAGE. 360 Degrees. RANGE Approx. 200 miles.

HEIGHT. Up to between 25,000 & 30,000 feet.

FUNCTION To detect aircraft up to long range, but at lower heights than is possible with C.H.

ACCURACY. Accurate information obtained by virtue of narrow beam.

TECHNIQUE. Beaming.

C.H.L. AERIAL ARRAY.

The aerial array consists of 4 stacks of 4 dipoles or 5 stacks of 4 dipoles.

Supporting grid & reflector.

Dipoles. C.T & R. 5 micro secs.

PIVOT. Revolving 4 - 6 times per minute through 360°

Supporting platform.

Tower.

30,000 ft.

Aerial array.

Pivot.

Pear shaped lobe of energy.

200 miles.

Tower.

As can be seen from the previous diagram the C.H.L. aerial revolves around its own axis thus giving "All Round Coverage".

As with C.H. the energy is transmitted from the dipoles over a given area, but in this case the dipoles are C.T & R (Common Transmit & Receive). That is to say:- The dipoles transmit for 5 micro seconds and then receive for a similar period. The returning energy is fed down feeder lines into the C.H.L. Cabin, where once again a Cathode Ray tube translates energy into aircraft position.

There are two C.T.Rs in the cabin, one up to 90 miles on the P.P.I (Plan Position Indicator) and the other, a Long Range tube which covers the remainder of the distance up to 200 miles. They are used in conjunction.

The P.P.I. employs a Radial Time Base, while the L.R.T. operates on a Horizontal Time Base. The aircraft position on P.P.I is shown by a "BLIP" and the position is read from the centre of the inner edge, in Fighter Grid form.

This is told to the T.P.T. and by virtue of the narrow beam the plots from C.H.L. are accurate in both range and bearing and do not require filtering.

C.H.E.L. (CHAIN HOME EXTRA LOW) TYPE 55 RADAR.

COVERAGE. 360 degrees.

RANGE. 200-000 yds. (60 miles on P.P.I. Remainder on L.R.T.)

HEIGHT. Up to 5,000 feet.

FUNCTION. To detect low flying a/c down to sea level and to report on the movement of shipping.

ACCURACY. Very accurate information obtained.

TECHNIQUE. Beaming (Parabloid).

NOTE. CHEL is also used to pass "NUBEX" reports on clould formation.

(a) Top height.

(b) Bottom height.

(c) Density.

(d) Speed.

(e) Direction.

TYPE 13 CENTIMETRIC HEIGHT FINDING GEAR.

COVERAGE. (1) Horizontally: 360 degrees.
(2) Vertically: 021 degrees.

FUNCTION. To find heights in conjunction with C.H.L. G.C.I. etc.

ACCURACY. Very accurate information obtained by virtue of very narrow beam.

TECHNIQUE. Beaming from scanning cheeze shaped parabloid.

When a CHL height is wanted, the duplicate P.P.I. operator in the CHL cabin turns the Type 13 aerial in the required direction by remote control. As the aerial scans up and down, so the time base on the height tube moves in conjunction and where the a/c blip appears on the height scale the height is read off in thousands of feet.

A ghost trace, (a permanent line of light) on the duplicate P.P.I. shows at a glance in which position the "cheeze" is facing.

I.F.F. Mk. 10.

Raid Reporting stations in Fighter Command and allied operational aircraft are being progressively fitted with I.F.F. Mk 10.

Modes of Operation.

This equipment has three interrogation channels known respectively as Mode 1, Mode 2, and Mode 3. The interrogator can be interlaced by a maste selector switch located in the Radar office to interrogate on more than one mode at a time.

The primary interest of raid reporting is in Modes 1 and 3 "interlace operation.

The I.F.F. response is displayed on the P.P.I. provided that the P.P. selector is positioned to accept one of the modes operated by the interrogator.

Aircraft Distress Signals.

In addition to the three modes, when an aircraft emits an I.F.F. Mk 1 distress signal, this signal will be displayed at any ground station operating I.F.F. Mk. 10, irrespective of the interrogation mode in use.

P.P.I. Display.
The normal Radar response from an aircraft and I.F.F. Mk. 10 response from the same aircraft are separate echoes on the P.P.I. display. It is therefore possible for Mk 10 I.F.F. responses to appear alone at ranges greater than the detection range of the radar for the aircraft type in question.

Similarly, if the radar is unserviceable, but the radar head upon whi the I.F.F. aerial is mounted is rotating, an I.F.F. response will appear provided that the P.P.I. display console is serviceable.

Response Shape.

The radar response is normal, and appears as a dot, (Type 14) whilst the Mk. 10 I.F.F. appears as one or more separate arcs which are substantially concentric with the radar responses and which appear closely adjacent.

Radar & I.F.F. Response Appearance.

MODE 1.
A single I.F.F. arc is painted adjacent to the radar response.

MODE 2.
Two I.F.F. arcs are painted adjacent to the radar response.

MODE 3.
A single I.F.F. Arc is painted adjacent to the radar response. It is essential that the P.P.I. observor is aware of the Mode being used for interrogation in order that Mode 1 responses shall not be reported as Mode 3 and vice-versa.

DISTRESS SIGNALS.
Four I.F.F. arcs are painted adjacent to the radar response.

AIRCRAFT OUTSIDE RADAR DETECTION.
At ranges beyond radar detection range, or when the I.F.F. equipment is operated by itself, the radar responses will not be present.

Function of I.F.F. Mk 10.

(a) To aid the recognition of friendly operational aircraft.
(b) To aid friendly fighter identification.
(c) To aid the continuity of tracking friendly aircraft, outward bound beyond radar range.
(d) To give early warning of the approach of friendly aircraft at ranges in excess of radar detection.
(e) To give notification of friendly aircraft in distress.

Mode Function.

Mode 1.
Identification and recognition of operational friendly aircraft, without discrimination of friendly fighters.

Mode 2.
Identification and recognition of a particular friendly fighter for control purposes.

Mode 3.
Identification and recognition of friendly fighters actively engaged upon air defence sorties, and for special recognition purposes by other classes of friendly operational aircraft.

Operating Instructions. (Reporting)

(a) The interrogator is to be operated throughout all periods of raid-reporting, and whenever the control element is operating.
(b) At stations where the primary function is raid-reporting, the interrogator is to be normally interlaced for Mode 1 & 3 operation.
(c) Additionally, immediate switching at the radar office to Mode 2, (Control) operation is to be effected upon request by the control element. Reversion to interlaced Modes 1 & 3 operation is thereafter to be effected as soon as possible.
(d) At stations where the primary function is fighter control, the reporting element is to request that the interrogator is returned to Modes 1 & 3 interlaced operation whenever Mode 2 operation is not required for control purposes, and is to make specific requests for Mode 1 & 3 interlaced operation when necessary in order to interrogate long-range tracks.
(e) The Duty Supervisor is to ensure that P.P.I.'s having Mk 10 I.F.F. displays are switched to receive Mode 1 & Mode 3 signals alternately, at intervlas of two minutes throughout the watch. He is also to ensure at all times that each P.P.I. observer knows which Mode his P.P.I. is accepting.

TELLING PROCEDURE. (Track Telling Cabin.)
(a) P.P.I. Observer.
i He is to report Mk 10 I.F.F. By Mode.
(b) ACCOMPANIED I.F. Response (Modes 1 & 3.)
Upon the appearance of an I.F. response accompanied by a radar response, he is to report the:-
Direction (if apparant)
Georef position of Radar Response
Strength
I.F. Mode.
e.g. NORTH WEST - MIKE FOX - 1230 - THREE PLUS - I.F. MODE ONE. or

NORTH EAST - MIKE FOX - 1854 - ONE - I.F. MODE THREE.
(i) Where the response has been Mode 1 interrogated, is then Mode 3 interrogated, and responds, he is to pass this information with the next plot:-
NORTH WEST - MIKE FOX - 1131 - ONE - NOW I.F. MODE THREE.
(ii) He is to pass the information (either I.F. Mode One, or I.F. Mode Three) with each plot until the I.F. Response disappears, and he is then to pas "I.F. OFF" with the next plot e.g:-
NORTH WEST - MIKE FOX - 1033 - THREE PLUS - I.F. OFF.
(c) Unaccompanied I.F. response.
Upon the appearance of an I.F. response unaccompanied by a radar response, he is to report the Georeg position, and Mode of response as follows:
(i) MODE ONE I.F. - MIKE FOX 1234
(ii) MODE THREE I.F. - MIKE KING 1734
He is to track such responses by chinagraph on the C.R.T. and is to pass the DIRECTION after the first plot:-
MODE ONE I.F. - NORTH WEST - MIKE FOX 1026
He is to fade such tracks as follows:
MODE ONE - I.F.- MIKE FOX 0926 FADED

S.O.S.
He is to give priority to the reporting of distress signals and is to prefix any such plots by "S.O.S.", e.g:-
S.O.S. - NORTH WEST - MIKE FOX 1234 - ONE

CONTINUITY PLOTTING PROCEDURE.
(a) Each continuity plotter is to mark unaccompanied I.F. responses at the appropriate "GEOREF" position on the continuity table in chinagraph as follows:-
(i) MODE 1 I.F. -
(ii) MODE 3 I.F. -

(b) He is to allot a track number to such plots by interjection technique immediately the P.P.I. observor passes the plot, e.g:-

P.P.I. Observor "MODE ONE I.F. - MIKE FOX ONE TWO TWO ZERO"
PLOTTER "TRACK TWO"

(c) Under the direction of the Supervisor he is to associate and join subsequent plots to form a track thus:-

(d) He is to write the C.F.P. designation against the track in the normal manner, when received, calling the internal track number "free." Thereafter he is to refer to the track by the C.F.P. designation, which he is to interject in the normal manner after each plot.

(e) He is to fade such tracks by the normal symbol.

(f) When he is Type 80 plotter, he is to interject I.F. plots emanating from F.P.S. 3 Radar, under the direction of the Supervisor.

ACCOMPANIED I.F. RESPONSES.

(a) Where the P.P.I. observor passes a radar plot accompanied by an I.F. indication, e.g:-
"NORTH WEST-MIKE FOX-ONE TWO THREE FOUR - THREE PLUS - MODE THREE" the plotter is to interject the hieght and track designation in the normal manner, e.g.
- "AT THREE-SIX - FIGHTER FOUR ZERO ONE"

(b) He is to record I.F. against the track, after the ancilliary information thus:

THE RECORDER.
The recorder is to use the following symbols:-
(a) MODE 1 I.F. 1
(b) MODE 3 I.F. 3

MARK 111 I.F.F.

G - BAND I.F.F. DISPLAYS.

When Mk 111G I.F.F. is operating, the I.F. Responses appear as castillations. Such indications are to be reported by the P.P.I. observor as "FIGHTER I.F." as follows:-

NORTH EAST - MIKE FOX - ONE ZERO THREE ZERO - THREE PLUS - FIGHTER I.F."

The plotter is then to interject the height and track designation in the normal manner:-

"AT THREE SIX - FIGHTER FOUR ZERO ONE"

He is to record I.F. against the track, after the ancilliary information thus:

The recorder is to use the same symbol.
When the I.F. response fades this will be reported as "I.F. OFF".

A-BAND (A-SCOPE) DISPLAY.

When the I.F.F. Mk 111A is operating the I. F. response will appear:-

(a) On the I.F. Trace of the range tube at C.H. stations
(b) On the console Type 61 I.F./C.R.T. at beamed stations, on the I.F. trace.

(i) AT BEAMED STATIONS. (I.F. aerials fitted to Type 13 array)

When instructed by the supervisor to interrogate an aircraft wigh A-BAND I.F. the height plotter is to direct the azicator operator to the targer. The azicator operator is to move the strobe until it cuts the required response. The height reader is to report as "ALLIED I.F." any I.F. indications aligned with a response on the main radar trace by the electroni amber line. The height plotter is to write against the track interrogated or is to report "No I.F." The information is then to be interjected by the appropriate continuity plotter after the strength has been passed by the P.P.I. observor.

S.O.S.

Broad "G" or "A" BAND distress signals are to be reported as for I.F.F. Mk 11.

CONSOLE TYPE 61. (Type 13 Height console)

Introduction.

Console Type 61 is a height range console generally used in conjunction with the P.P.I. consoles Types 60 and 64. At fixed ground radar stations consoles type 61 are installed in the Interception and Track Telling cabins i.e. they may be used in G.C.I., C.E.W., and C.H.E.L. stations.

Function of Console Type 61.

The function of Console Type 61 is to provide height finding facilities for various "users." These facilities may be presented in two ways; firstly, to give an elevation-scan presentation of responses from radar Type 13 heads (aerials), or, alternatively, to give a range/deflection display of responses from radar heads Types 14, 15, and 54. When used on Type 15 stations, an external multivibrator is included to provided height/ finding facilities using the "Split" technique.

Components of Console Type 61.

The following are the components of Console Type 61:-

(1) Indicating unit (C.R.T.)
(2) Indicating unit (I.F.F.)
(3) Timebase unit (C.R.T.)
(4) Timebase unit (I.F.F.)
(5) Power units
(6) Control Panels

Indicating unit (C.R.T.)

The indicating unit is used for presenting the main radar responses either as "Y" deflection (blips) upon a linear horizontal time base trace when presenting radar Types 14 or 15, or as intensity modulation upon an elevation scan as in radar Type 13. The indicating unit panel houses a number of controls which are described under the heading "CONTROLS".

A transparent strip carrying three range scales can be fitted across the horizontal diameter of the tube; these scales are graduated in nautical miles, Range 1 being engraved in RED, Range 2 in AMBER and Range3 in GREEN. The range is selected by a range switch on the right-hand side control panel upon which an indicating lamp of corresponding colour is illuminated. The scale is illuminated by a lamp at each end: four lamps are also fitted to provide a low level illumination of the C.R.T. screen.

When elevation scan presentation is required, the above-mentioned scale is not fitted. The working range is pre-determined (140 miles) and a corresponding height range graticule is produced, partly by electronic means, and partly by direct painting upon the face of the C.RT. The vertical range lines and sloping 5^c elevation strobes are produced electronically, and the constant height lines are painted.

Intensity Modulation.

When Console Type 61 is used to display Radar Type 13 information, the video signals are applied to the Grid of the C.R.T. and thence to the screen face by way of the electron beam. When used with other types of Radar, e.g. Type 14, the video signals are applied to the "Y" plates, with a small fraction diverted to the grid to brighten the trace during the action reception of the video pulse (signal)

Indicating Unit (I.F.F.) & Time-base Unit (I.F.F.) A-Band I.F.F.display.

The indicating unit (I.F.F.) and time-base unit (I.F.F.) together form a display system for the presentation of I.F.F. Mk III A-Band responses.

The I.F.F. responses are displayed upon a 6-inch cathode-ray tube fitted in the indicating unit. The presentation is given upon a double time-base trace, one of which shows the I.F.F. responses, the other, the main radar responses; this is done to facilitate range correlation between the I.F.F. and the radar.

The radar responses may be derived from the H/R console itself, or from the associated Console Type 60 or 60A (P.P.I.)

Calibration pips (range marks) also supplied via the P.P.I. Console are displayed for setting-up purposes.

Time Base Unit (I.F.F.)

The time-base unit receives a locking pulse from the radar TX and generates a locking pulse at a reduced P.R.F. which triggers the I.F.F.Interrogator. A return lock from the interrogator is used to initiate the I.F.F.

trace upon the C.R.T. while the main radar locking pulse initiates the radar trace. (See Fig 2.)

Strobing System.
A strobing system is incorporated in the display system, for use when the A-Band I.F.F. signals are to be correlated with the radar display on the P.P.I. Console. A strobe pulse appears on the P.P.I. Screen at a range determined by the setting of the "STROBE" control on the P.P.I. Console. As the P.P.I. trace rotates, the strobe pulse paints a fine circle upon the P.P.I. screen, and the P.P.I. operator adjusts the "STROBE" control the circle intersects the response which is to be interrogated.

The movement of the Strobe control on the P.P.I. causes a strobe indication to move to the corresponding range on both traces of the I.F.F. display unit. At this point, a small portion of each trace is brightened and expanded, the beginning of the expanded portion being marked by a vertical "ruler line" which cuts both the traces, and so marks the range corresponding in position with the strobe pulse on the P.P.I. display.

Power units.
They supply power to the time-base units, the indicating units and the control panel units.

Panel units (Control.)
There are two panels on console Type 61. The panel on the left-hand side of the H/R Tube carries two operational components, namely the "RANGE MARKS AMP." control and the "ON/OFF" switch for starting and stopping the tilting motor for the Type 13 aerial.
The panel on the right hand side of the H/R Display tube contains the following:-

ON/OFF Switch
"GAIN" Control
I.F.F.Gain Control
"N.B.W. IN" Key
S. T.C. In Key
L.P.F. IN Key
TOP PHASE, ANTI-PHASE Control
AZIM IND. Switch
ELEV. STROBE Switch
P.P.I.STROBE Switch
CALIB. Switch
HEIGHT PHASE NORMAN Switch
"A" BANK Switch
RANGE Switch
P.R.F. Switch
(HALVED
(NORMAL
(SMALL SHIFT.

The functions of the above switches are discussed under the heading "CONTROLS".

Signal Presentation.
In the Type 13 application, the signals are applied to the C.R.T. as intensity modulation, the vertical deflection plates("Y") being used to produce the elevation scan. In effect the tube is used in a similar manner to an expanded Sector P.P.I. Display except that the sector is scanned in elevation instead of in azimuth.
In all ather applications, the signals are presented on the C.R.T. as vertical deflections of a horizontal time-base (blips) together with a small amount of intensity modulation which brightens the trace over the extent covered by the echo.
Since the console is arrayed to give either "Elevation-scan" or Range/Deflection presentation, change-over links of the indicating unit are available to effect the above.

The console also provides facilities for the display of A-Band I.F.F. responses from friendly aircraft and surface vessels; correlated in range and azimuth with the corresponding radar responses. It is necessary to stop the rotation of the aerial and train it on the desired azimuth, in order to interrogate.

Elevation-scan display.

The elevation-scan display is only used with centimetric height-finding equipment such as Radar Type 13. In this application a normal is applied to the "X" plates of the C.R.T., but the video signals are introduced in the form of intensity modulation of the beam. The aerial array radiates a beam which scans continuously in a vertical plane. The amount of angular movement of the beam in the vertical plane is from -1° to $+20^{\circ}$, the horizontal being considered as zero (0°).

The aerial sweeps over this range six times per minute, so that the time of a complete sweep is ten seconds.

The amplitude of the time-base sweep is controlled by a magslip (see precis on aerials for fuller treatment "Magslip"), driven by the aerial scanner. The time-base so produced pivots about a point at the bottom left-hand side of the tube face, and moves in synchronism with the motion of the aerial.

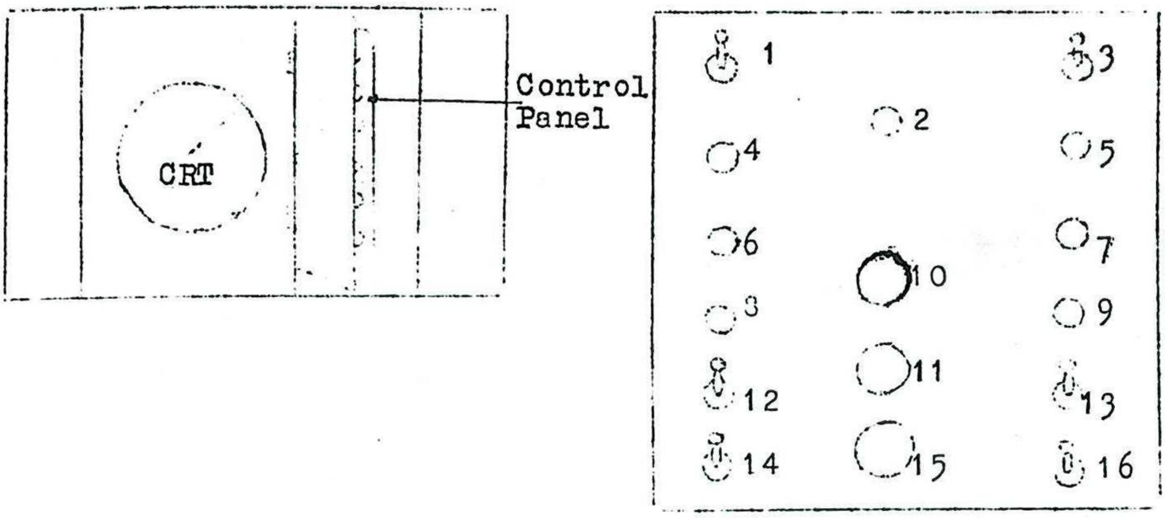
If the radiated beam sweeps over an aircraft, the trace is brightened by the effect of the returning radar signal, which is applied to the C.R.T. beam as intensity modulation. As a result a bright vertical line appears on the tube face, the position depending upon the height and range of the aircraft.

It is important to remember, that the short range is given by the distance along the "X" axis, instead of the distance along the trace as in the P.P.I. display. Allowance must be made for the curvature of the earth, and the horizontal of the C.R.T. face corresponds with an angle of minus one degree (-1°). (See Fig. 3. for graphical explanation of elevation scan/slant range.)

Controls.

See appendix to this precis.

CONSOLE TYPE 64



The indicating unit of the console Type 64, has a control panel on the right hand side, located under a small lockable door. This panel carries the following controls:

1. Anti-clutter Switch- this reduces the brilliance for the first few miles of the trace, to cut down the disturbing influence of the permanent echoes.

2. Sector Switch)
3. Head Combination Switch) - These form the controls of the sector sweep facility. The selector switch can select any one of the pre-set sectors and the facility is brought into operation by closing the head combination switch.

4. Radar Signals- input control, radar gain.

5. Video Map- input control, video map brilliance.

6. Strobe Markers- brilliance control for inter-trace strobe markers.

7. Range Strobe- brilliance control for range strobe marker on azicating P.P.I.

8. I.F.F.- input control, I.F.F. gain.

9. Range Rings- input control, cal. amp. control.

10. Off Centre Vertical) X & Y shifts.
11. Off Centre Horozontal)

12. Screen Lights Switch- ON/OFF switch for lights around the C.R.T.

13. Screen Lights Brightness- two position switch giving two degrees of brilliance for the screen lights.

14. H.T. Reset Button.

15. Range Switch- four position switch marked 80,160, 240 & 320 nautical miles. These are tube DIAMETER ranges.

16. H.T. ON Switch- this together with the H.T. Reset are not normally used by the operator, unless the H.T. 'trips', in which case the Reset will be used. The H.T. ON Switch is normally left in the "ON" position.

CONSOLE TYPE 65.

General Description.

The console type 65 (Type 7 heights tube) is a mains-operated display unit installed in the interception and track-telling cabins at fixed G.C.I. stations. Radar responses only are displayed on this console. (See Fig. 1 for simple diagram of console Type 65.)

Function of Console Type 65.
The function of the console is to ascertain the height of an aircraft by measuring the ratio of the amplitude of responses given by a combination of two aerials. For this purpose, certain combinations of two aerials are selected for comparison of signal strengths by a gate-switch situated on the left-hand side of the screen. The signals of both aerials are displayed upon a horizontal time-base, the signals taking the form of vertical deflections ("blips")

Components of Console Type 65.
The following are the components of the Console Type 65:-

(1) Amplifying unit
(2) Time Base unit
(3) Indicating unit
(4) Power unit
(5) Panel Control unit

(1) Amplifying unit.
This unit accepts the returned radar signal and having suitably amplified it, passes it on to the "Y" deflection plates of the C.R.T. It also provides "Intensity Modulation"

(2) Time Base unit.
This unit produces the time base or trace, and the calibration pips.

(3) Indicating unit.
The Indicating unit consists of a Cathode Ray Tube and its mounting. The C.R.T. receives the returned signals which when amplified are applied to the "Y" plates. Since two aerials are being used, two signals will appear on the trace, the vertical length of each echo or "blip" being proportional to the strength of the signal received in each aerial. The proportion of signal strength is then optically compared and applied to the manual calculator. For a fuller treatment of the manual calculator see the precis entitled "Height Finding."
A perspex range scale is placed under the linear trace, where the range of an aircraft may be read off directly. The tube is calibrated in 5 mile graduations and possesses a maximum range of   miles.

(4) Power unit.
This unit supplies power to the various "users" (time base unit etc.) within the console.

(5) Panel Control unit.
The Panel Control unit houses the aerial selector, the "Split on/off" and the "Split Separation" switches and the gain control.

Method of height assessment.
In brief, the method is to compare the strengths of radar responses received from an aircraft, upon two aerials mounted one above the other at different heights. The angle of elevation is found from the ratio of the two responses, and the height is then determined in conjunction with the range of an aircraft. The manual calculator (See Fig.2.) is uses to translate the signal relationship into height.

It is operationally desirable to use the same aerials for the purpose of plan position indication as well as for height-finding. For P.P.I. representation however, a continuously rotating aerial system is necessary. This rotation is preferably at about 4 to 6 r.p.m. so that sufficiently "fresh" plots are always available. The amplitude comparison necessary for height-finding must therefore be taken during the short period when the target is within the beam, a C.R.T. of medium persistence (afterglow) being used to hold a response.

Split Technique.
To compare the amplitudes of the selected responses they are presented side by side upon the C.R.T. screen, this technique being referred to

"split". This is achieved by displaying the two responses on different time-base traces, and displacing one trace laterally with respect to the other. The operator estimates the ratio of the two responses by eye, the smaller amplitude being expressed in "tenths" of the greater, e.g. a ratio of 1.0 to 0.6 is reported as 10:6 of the left hand signal is the larger, and as 6:10 if the reverse is the case.

Certain ambiguities arise when this method of height-finding is used, but in practice these are resolved by a system of phase-checks. A gate-switch (aerial selector switch) is fitted on the control panel for this purpose.

Aerial Selection.

In the practical application of this system, three (3) separate aerials are mounted on a vertical screen; these are arranged as follows:-

(1) A 4-bay, 4-stack array of full-wave horizontal dipoles at a mean height of 5.3 λ (approx, 25 ft) above the ground. This is known as the top aerial.

(2) A 4-bay, 2-stack array of similar dipoles at a height of 2.65λ above the ground, called the middle aerial.

(3) An array similar to the middle aerial, but only 1.6λ above the ground, called the bottom aerial.

A capacity switch in conjunction with a specially designed feeder network, enables the three aerials mentioned to be used for both transmitting and receiving, in the following sequence, namely

TOP, MIDDLE, MIDDLE+ BOTTOM, BOTTOM.

The aerials operate in this sequence on four successive pulses of the transmitter, the sequence being repeated indefinately. The selected aerial combination remains in circuit long enough to allow a reflected signal to be received from extreme operational range, to reach the receiver.

During each of four successive time-base periods, a signal is received from one of the four aerial combinations, in the sequence TOP, MIDDLE, MIDDLE + BOTTOM, BOTTOM.

The gate switch already referred to permits selected square waves to be used for blanking out two of the four timebases associated with the complete sequence, and the other two waveforms are used to produce the split waveforms by which one of the two traces is displayed to the right.

When the gate-switch is in the centre position all four time bases are displayed without split, so that the four incoming responses are superimposed to appear as a single response on the H/R Tube.

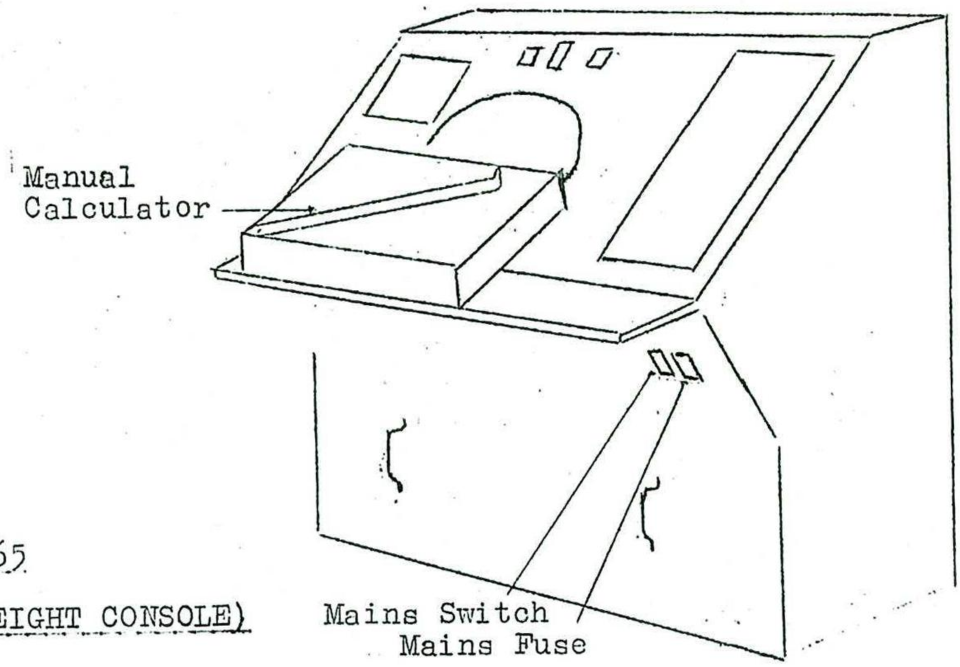
The other four positions are labelled

RIGHT CHECK
LEFT CHECK
LOW HEIGHT
HIGH HEIGHT.

(SeeFig.2 for diagram of aerial selector switch positions.)

Controls.

For Controls (External) see attached diagram (Fig. 4)



CONSOLE TYPE 65

(RADAR TYPE 7 HEIGHT CONSOLE)

Fig. 1.

TYPE 7 HEIGHT CONVERSION CHART (MANUAL CALCULATOR)

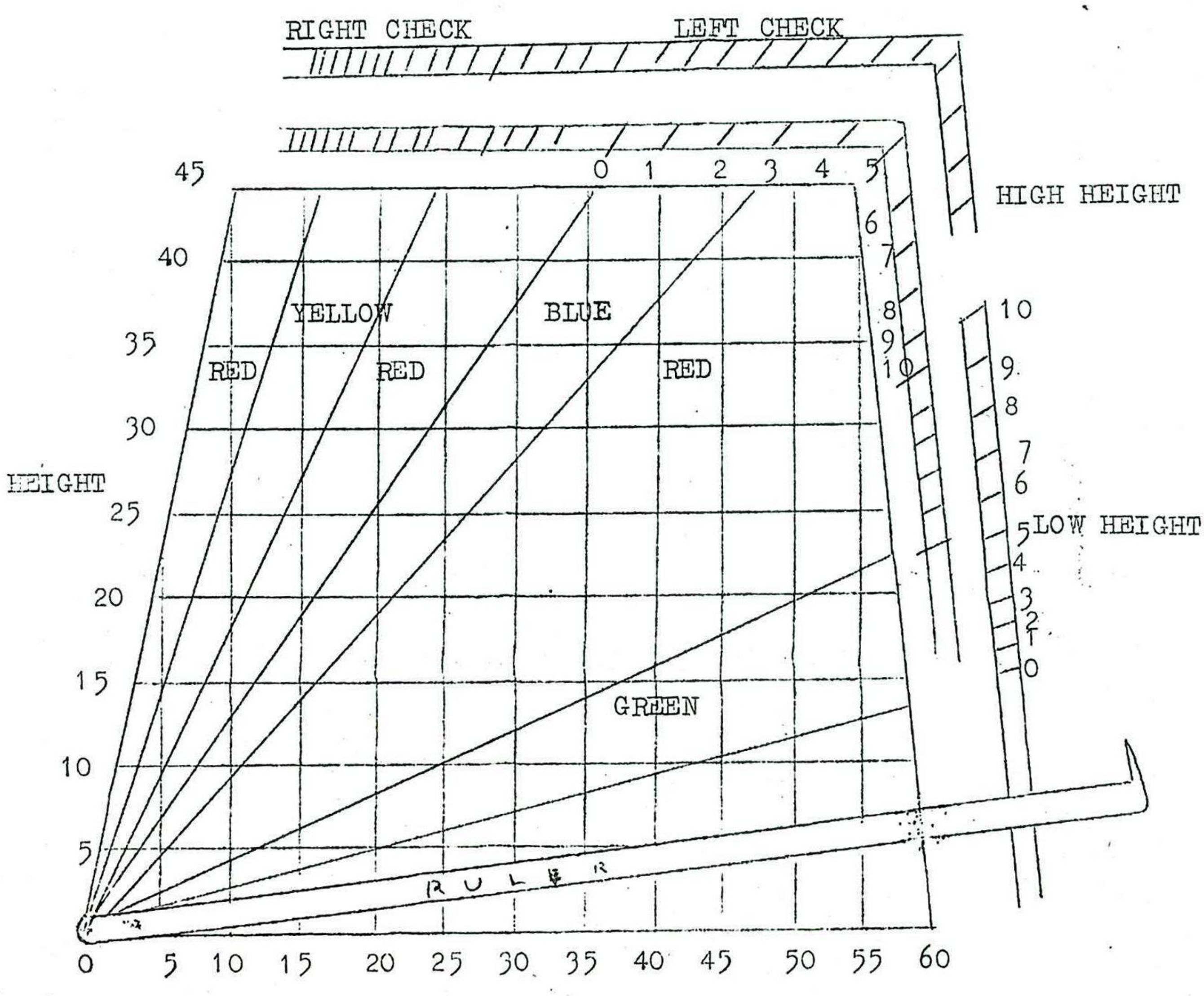
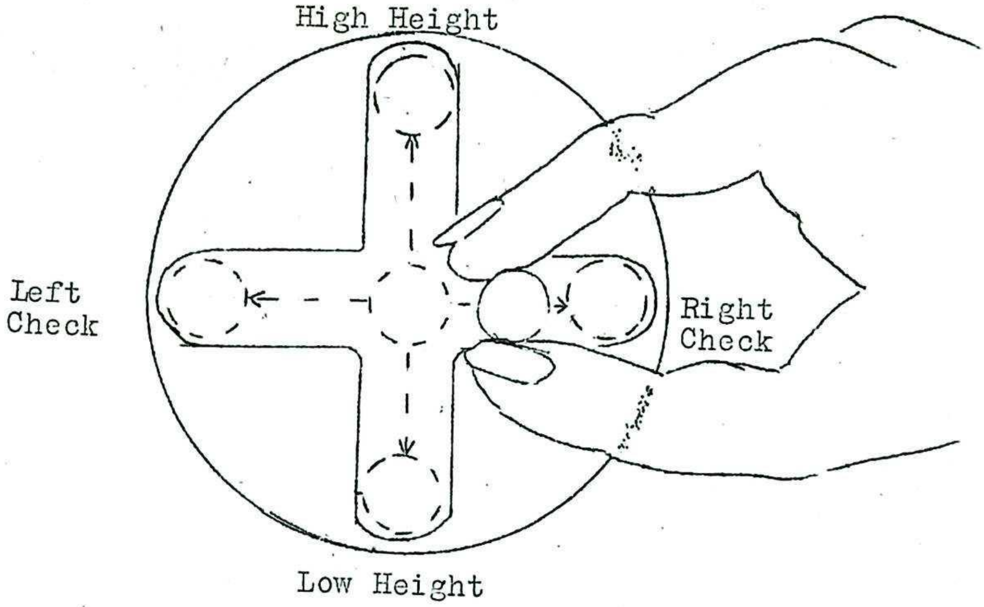


Fig. 2



TYPE 7 HEIGHT/RANGE TUBE AERIAL SELECTION SWITCH

Fig. 3

EQUIPMENT	FUNCTION	AERIAL	RANGE	COVER
C.H.	Reporting of high flying medium and lomg range aircraft	Separate Tx and Rx.Floodlight Technique	200 n.mls.+ tube calibrated to 300n.mls.	Vert. $1\frac{1}{2}^{\circ}$ - 25° Horiz 60 - 80° either side of L.O.S.
Type 7	Reporting(C.H.B) and G.C.I.	Combined Tx and Rx Beamed Technique Beam width 10°	150n.mls +	Vert. fairly full cover from 1.5° to 20° Horiz, 360°
Type 14 Mk 8	Reporting (C.E.W.) and G.C.I.	Combined Tx and Rx Beamed Technique Beam width $1\frac{1}{2}^{\circ}$	approx 100 n.mls depending on angle of elevation	Vert. $8\frac{1}{2}^{\circ}$ Horiz 360°
Type 14 Mk 9	Reporting (C.E.W.),G.C.I., and Rats and Naval Repoting (C.H.E.L.)	Combined Tx and Rx Beamed Technique Beam width $1\frac{1}{2}^{\circ}$	120 n.mls +	Vert $4\frac{1}{2}^{\circ}$ Horiz 360°
Type 13	Height Finding Plan Positions can be found	Combined Tx and Rx Beamed Technique Beam width $1\frac{1}{4}$ By 5°	150 n. mls.	Vert. 20° Horiz 360
F.P.S.3	(1) Reporting of long range med. and high flyimg aircraft (2) Overland reporting (3) G.C.I.	Combined Tx and Rx Beamed technique Beam width 1.3°.	300 n.mls	Vert 10° approx. with gaps Horiz 360°
Type 54	(1) Reporting of Rats and Shipping (C.H.E.L.), may also have Rats control function	Combined Tx and Rx Beamed Technique Beam width 2°	120 n.mls	Vert. 2° Horiz 360°

	C.H.	Type 7	Type 14 Mk.8	Type 14 Mk 9	F.P.S.3	Type 54
W/L	10 - 15 mtre.	1.5 mtrs	10 cms	10 cms	23 cms approx.	10cms

OPERATION OF GROUND CENTIMETRIC D/F UNIT

The gound centimetric D/F unit is a mobile radio installation consisting of a wide-band receiver which has D/F (direction finding) capabilities, capable of receiving pulse transmissions from "S" (cms) and "X" (cms) bands centimetric radar.

Function

The function of the D/F unit is to report the presence of enemy aircraft by detecting airborne navigational/ bombing radar and by association of the radar transmission characteristics to aircraft types, to provide "intelligence" about enemy aircraft.

Only azimithal bearings are obtained, and the installations are deployed at different geographical locations (coastal radar stations) and simultaneous bearings are taken for triangulation to provide a plan position fix. Triangulation takes place at the C.F.P. under the control of the D.R.W. Supervisor.

Principals of Operation

Two aerial horns are mounted in such a position as to give overlapping polor diagrams. The aerial is rotatable through 360 degrees in azimuth.

The signals are fed to the "X" and "Y" plates of a C.R.T. and displayed as a "plume" of luminescence. The aerial is rotated until the plume is a vertical central deflection on the C.R.T. at which position the detected radar is dead ahead. The bearing angle, with reference to a previously established datim-line is then measured by means of a scale attached to the rotating mechanism. To give the maximum chance of seeing a small number of pulses, a "bright-up" circuit gives a brightening pulse when a signal appears from both or one aerial horns.

An aural output is provided for monitoring purposes and very weak signals may be heard before they are capable of C.R.T. identification. Signals are detected by a series of clicks or pips as the aerial is rotated; the signal being loudest when dead ahead of the aerial. Aural monitoring (listening out) reduces operator fatigue since the C.R.T. need not be scrutinized until the signals have been heard.

The installation should be set up so that "true" bearings of signals are taken. Manual controls are provided for "BRILLIANCE" and Focus.

Setting-up Procedure

a. Switch on mains power supplies to the vehicle.

b. Switch on main cabin supply and allow heaters to remain on for a period sufficient to "dry-out" the cabin.

c. Switch on the receivers.

d. Switch on the power unit (the fan motor should now be heard).

e. Allow a warm-up period of five minutes and check "Squint" by switching on the test signal and adjusting the "Adj-Squint" control to bring the test signal centrally and vertically positioned on the C.R.T.

f. Adjust the gain and other controls to a suitable working level.

Operational Control

The operating team will consist of:-

(a) An operator
(b) A "teller" to record and tell bearings to the C.F.P.

The operator is to wear a headset and search for aural indications of all types of pulse trnasmissions. When signals are received initally, he will obrain the bearing from the C.R.T., and by using a stop-watch, the sweep rate. He is to say "NOW" whenever a bearing has been determined together with the sweep rate of the signal.

During peace time exercises the type of airborne transmissions received will be from H2S MK IV radars with a sweep rate of approximately 60 r.p.m. Operators are to learn to distinguish between these signals and transmissions received from shipping. In war time P.R.F. and sweep rates of enemy airborne radars would be passed to units to assist in identification.

The teller is to wear a head and breast set and be in direct landline communication with the operator on the triangulation table at the C.F.P.

When the operator says "NOW", he will pass the bearing and sweep rate, e.g. TWO SEVEN ZERO - SWEEP RATE SIX ZERO, and record on sheets as shown below, details and times of all information passed.

All records are to be passed to the Senior Radar Supervisor at the parent station concerned at the end of both watch period or where the unit is located remotely from the parent unit, at times indicated by him.

The Senior Radar Supervisor (or Senior Operator in the case of "Readiness" stations) at the parent radar concerned will be responsible for the manning, crew training, and operational efficiency of the Unit.

ATMOSPHERIC EFFECTS ON RADAR.

Introduction.

16.1. The effect of day to day weather conditions upon the performance of radar stations is more extensive than may, at first, be expected. This chapter sets out the main outlines of this particular subject; experience will teach the student much more.

16.2. In the Mediterrean and Far Eastern zones the weather conditions will vary between limits far more widely spaced than those around the British Isles, and their effects will, therefore, be correspondingly greater. The variations in performance of a radar to be expected from any given set of weather conditions is, of course, uncontrollable and, largely, unpredictable; experience will, however, enable the Supervisor to anticipate some of the variations, and to recognise others.

Scope of Chapter.

16.3. The subject will be dealt with under the following headings :-

(a) Wind, Rain and Mist.

(b) Sun.

(c) Normal Atmospheric Refraction.

(d) Conditions causing Abnormal Propagation.

(e) Severe Atmospheric Refraction.

(f) Anomalous Propagation.

(g) Effects of Abnormal Propagation.

Wind, Rain and Mist.

16.4. If the wind force is sufficiently great it may be impossible for the broadside arrays of the metric beamed equipments, and the solid metal reflectors of the Type; 50 series, to continue turning. Such wind strengths do occur around the coast of the British Isles, although not very often.

16.5. Even a moderately high wind can whip the surface of the sea into waves, however, and thus obscure the displays of centrimetric radars with wave-clutter. This wave-clutter, for the most part, is only an irritation to the observer; the occasions when large areas of the station's cover are completely obliterated being few in number.

16.6. The direct results of rain and mist are negligible, the interference caused on the C.H. display being, again, only an irritation to the observer; an irritation which can be largely removed by the use of the appropriate coloured filter. The rain-clouds themselves will be displayed on the C.T.T.s of Centimetric stations, and the previous remarks relating to wave-clutter apply to cloud responses also.

16.7. The secondary results of rain and mist are more serious. Intense sparking can be caused by voltages arcing-over on water-drenched insulation posts, which will cause considerable disturbance on the display. In addition, the performance of the equipment can be seriously reduced by the loss of signal occasioned by leakage to earth from the feeders, or, in the case of centrimetric equipments, the collection of moisture inside the wave-guides.

Sun.

16.8. One of the effects of the sun on the earth is produced by the absorption of the invisible ultraviolet light of the sun in the atmosphere of the earth, particularly by water vapour and ozone. The energy absorbed by the earth's atmosphere does not disappear, the upper layers being changed by the act of absorption.

16.9. In these very tenuous layers at heights of 60 miles or so above the earth, the effect of absorption of ultraviolet light is to cause the emission of electrons from atoms of the air; i.e., the production of the "E" and "F" ionised layers, (see Chapter 5). These reflecting layers have a complex structure and the reflection of waves of different wavelengths takes place at different heights.

16.10. Since the structure of these atmospheric layers depends on the emission of ultraviolet light from the sun, it follows that if the intensity of this light should change there will be some reaction in the behaviour of any wavelengths normally affected by the ionised layers. As the sun goes through its cycle, it is believed that the average total intensity of ultraviolet radiation from its surfaces changes, due to the sun-spots and solar flares; there is, in fact, a well-marked correlation between the spottedness of the sun and the most suitable frequencies to be used for long-distance radio communication on the shorter wavelengths.

16.10. In addition to the increase in visible and ultra-violet light produced by a solar flare, it is almost certain that a stream of positively charged ions is also emitted. These are sprayed out into space, and if the flare happens to be suitably positioned on the sun, then, by the time the particles have covered the distance between the sun and the earth, the earth will run into the stream of ions. As well as producing the Northern and Southern Lights at the Poles, this moving stream of electricity will stimulate magnetic disturbances, known as magnetic storms, in the upper layers of the earth's atmosphere.

16.11. The effect of the foregoing activities will be as follows :-

(a) On Radio Communications: Radio fade-outs on frequencies normally satisfactory; increased static interference, making communication difficult.

(b) On Radar equipments : C.H. stations will be mainly affected, long range scatter appearing on the display. All types of radar will experience a slight increase in noise, which is not normally obvious, that will, of course, reduce the signal-to-noise performance of the equipment.

16.12. A second effect of the sun lies in the heating effect it has upon the surface and atmosphere of the earth, the temperature conditions thus produced playing there part in the atmospheric refraction of radio and radar waves, as described in the following section.

NORMAL ATMOSPHERIC REFRACTION.

16.13. As explained in Chapter 5, paragraph 5.11 (b), when a wireless wave enters a medium of different density it is bent in the direction of the denser layer. As the wave travels through numbers of thin layers of the medium, each of varying density, the wave is deflected from its previous path by each succeeding layer; this results in the original straight line of the propagation being translated into a curved path.

16.14. The amount of refraction which will be introduced by two media of any given density is measured by the refractive index of the media concerned. This index is the ratio of the sine of the angle of incidence to the sine of the angle of refraction, and it follows from this that :-

(a) An index of more than "1" means that the angle of the refracted ray is less than the angle of the incident ray; i.e. the ray is bent towards the normal.

(b) An index of "1" means that the angle of refraction equals the angle of incidence; i.e., there is no refraction.

(c) An index of less than "1" means that the angle of refraction is greater than the angle of incidence; i.e., the ray is bent away from the normal.

(d) The larger the index number the less the amount of refraction, and vice versa.

16.15. The refraction index of each pair of media in the atmosphere of the earth depends upon the balance of :-

(a) Temperature.

(b) Humidity.

(c) Pressure.

16.16. Under normal conditions, as altitude is increased from the surface of the earth the following will occur :-

(a) Temperature will decrease - causing the refraction index to increase.

(b) Humidity will decrease - causing the refraction index to decrease.

(c) Pressure will decrease - causing the refractive index to decrease.

16.17. When any of these components are taken singly, variation of pressure does not have so much effect on the refractive index as a variation of either temperature, or humidity. As the altitude is increased, however, the combined effect of the three is to cause the refractive index to decrease, i.e., the amount of refraction increases.

16.18. As a result the wave is, under normal conditions, bent from its straight path over a given distance by an amount which, for rough calculations, may be said to be equal to one quarter of the curvature of the earth over that distance; i.e., $\frac{1}{4} \times \frac{2}{3} r^2$, or 1/6 r2, where "r" is in statute miles, and the answer is in feet. Thus, the amount by which an electromagnetic wave would be displaced from the straight line of its theoretical path after travelling 100 statute miles would be 1,666 feet.

16.19. The existence of this curvature in the actual path of a transmission leads to extreme difficulty in making certain calculations. To overcome this, calculations are sometimes based on the "Larger Earth Theory", which averages out the errors introduced by refraction by assuming that :-

(a) The wave will travel in a straight line without bending.

(b) The effective radius of the earth is greater than the physical radius, (8,000 kilometres as compared to 6,370 kilometres).

16.20. Although in some text-books the reader is warned when the Larger Earth Theory is being used, in others the use of the figure "8,000 kilometres" for the radius of the earth is considered sufficient indication.

16.21. If, on increasing altitude, the effects are not as described in paragraph 16.16 in respect of temperature, humidity, pressure, or any combination of the three, then the amount of refraction will differ, and conditions ~~of abnormal~~ propagation are said to exist.

Conditions Causing Abnormal Propagation.

16.22. If the atmosphere is turbulent and unstable, as shown by the presence of rain, storms and high winds, it is not suitable for abnormal propagation. This is because the vertical currents present in the atmosphere will break up the layers of differing density, and will prevent new layers from forming. Neither does abnormal propagation thrive in cold climates, where the air cannot absorb large amounts of water-vapour.

16.23. Conditions for abnormal propagation will only be favourable where there no vertical currents, since in these circumstances steep gradients of humidity and temperatures will be allowed to form, and will remain undisturbed for considerable periods.

16.24. Hot, dry air blown from the land over the sea is a common cause of abnormal propagation; in Britain, during the summer months, the amount of abnormality will be moderate, but, in the Mediterranean and Far Eastern areas this factor will be coupled with the ability of the warm air to absorb large amounts of moisture from the sea, and can cause severe refraction for long periods during the hot part of the year.

16.25. The two main types of abnormality that are experienced are :-

(a) Severe Atmospheric Refraction.

(b) Anomalous Propagation, (sometimes called "Guided Radiation").

Severe Atmospheric Refraction.

16.26. When the normal state of affairs is reversed, and there is an increase of temperature with an increase in altitude, Temperature Inversion is said to occur. When temperature inversion is coupled with a sharp decrease in humidity the resulting refraction will be severe: so severe that a ray can be bent until it is returned to the surface of the earth.

16.27. Under these conditions the bottom lobe of a station may be bent until the tip of the lobe is depressed to ground, or sea level. This will result in :-

(a) A reduction of coverage for aircraft at normal heights.

(b) Increased, and abnormal, ranges for low-flying aircraft and surface vessels.

16.28. As stated previously, this often occurs when a strata of hot, dry air is blown from the land over the top of a strata of cooler, moisture-laden air above the sea. In the absence of any disturbing vertical currents, this condition of temperature inversion can last for some time.

16.29. Severe atmospheric refraction, in its various degrees, is immediately detectable on the radar display by the appearance of a number of P.E.s, many of them at long range, which are not normally visible.

Anomalous Propagation.

16.30. There is an atmospheric layer which is always in existence near the surface of the earth; while the lower atmosphere is receiving heat from the sun, this layer is very low, being about 10 feet overland, and 20 feet over the sea. At night-time, however, this layer increases in height to usually 500 feet, although it can rise to as high as 1,200 feet under certain conditions.

16.31. Radar waves can be trapped within this atmospheric layer, or duct, the height of the duct being critical for certain wave lengths, as shown below :-

	Wavelength.	Height of Duct.
(a)	7 metres.	1,200 feet.
(b)	1·5 metres.	750 feet.
(c)	50 centimetres.	350 feet.
(d)	10 centimetres	120 feet.

16.32. Should the duct remain static at the critical height for a particular radar, the entire lobe can be depressed and encompassed within the duct. This will affect the performance of the radar as follows :-

(a) Surface vessel, and low-flying coverage is afforded for the entire length of the lobe.

(b) There is a loss of coverage for medium high-f;ying aircraft.

16.33. It should be noted that the presence of Severe Atmospheric Refraction can help the duct to rise and form at critical levels.

Effects of Abnormal Propagation.

16.34. Not all the effects of abnormal propagation are disadvantabeous, as is shown below :-

(a) Advantages.

(i) Increased ranges are obtained on aircraft and surface vessels within the duct or area, illiminated by the bent lobe.

(ii) There is a modification to the degree of jamming that may be suffered from ground or airborn jammers.

(iii) The range of some navigational aids is increased.

(iv) There is an increase in the range at which some radio signals can be received.

(b) Disadvantages.

(i) Reduced range of detection of aircraft flying just above the duct, or bent lobe.

(ii) Errors are introduced into height measurement and estimation.

(iii) There is a reductio in the efficiency of the displays, due to the presence of increased clutter from P.E.s.

(iv) There is a reduction of the optimum flying height for A.S.V. fitted aircraft.

(v) There is a modification to the degree of jamming that can be inflicted on the enemy by means of ground, or airborne, jammers.

(c) General. The following may be advantageous, or dis-advantageous, depending upon circumstances :-

(i) There is a modification to the height at which our aircraft should fly to avoid detection by enemy radars.

(ii) Consideration of the frequency with which abnormal propagation conditions will occur in any given area may modify the choice of wavelength, (and, hence, the height of the site to be selected), that must be used to produce the desired coverage.

16.35. The precise effects of any type of abnormal propagation upon the particular equipment for which the supervisor is responsible, are, as has been said before, unpredictable; experience will, however, enable the supervisor to anticipate with a reasonable degree of accuracy the loss of coverage which will inevitably be suffered by the equipment. It is the responsibility of the Radar Supervisor to minimize, by the application of his knowledge and experience, the errors which can occur in the output of a Raid Reporting Unit during conditions of abnormal propagation.